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Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**802.16j (Mobile Multihop Relay) Technical Requirements**
Date Submitted	**2006 – 07 - 01**
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Re:	Submitted in response to Call for Contributions IEEE 802.16j issues on 2006-06-19
Abstract	This document is to propose technical requirements that need to be addressed by the IEEE 802.16 Task Group j
Purpose	This contribution is provided as input for 802.16j Technical Requirements.
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1. Introduction

1.1 Document Purpose and Scope

The purpose of this document is to propose the functional requirements that need to be addressed by the IEEE 802.16 Task Group j. Based on the 802.16j PAR and 5 criteria [1] and the 802.16j Usage Models [TBD], this document is intended to provide additional informative guidelines for proposals and specifications. This document defines not only the mandatory requirements but also the optional requirements for MMR-BS and RSs. Throughout this document, the significance of each requirement is defined via two adjectives:1) "Mandatory": the item is an absolute requirement. 2) Optional: the item will be addressed by the specification but its implementation is optional. That is, an optional item can be omitted for an implementation depending on target market. RSs are the new components of 802.16j MMR system and will be the majority part to be defined in the specification. We believe that the IEEE 802.16 Task Group j should include both mandatory and optional technical requirements as basis. Most of the requirements defined in this document have been harmonized with the contribution C80216j-06_050. A few optional requirements are highlighted in the tables shown in Section 3 in order to indicate that these need more discussions.

This document is a working document that presents an *estimate* summary for the functional requirements and scope of TGj, but it will also evolve as the TGs effort progresses.

Section 1 presents an overview of this document, high level requirements from the PAR, and general requirements of MMR network components. In Section 2, we propose functional categories. Section 3 defines the detail of each requirement within the categories defined in Section 2. Appendix A defines the terminologies used throughout this document based on [3] and [4]. This terminology is subject to change as the TGj develops an official terminology document [TBD].

1.2 High Level Requirements from PAR and 5 Criteria

To enhance coverage, throughput, and/or system capacity of 802.16 networks, the 802.16j amendment shall specify OFDMA physical layer and medium access control layer enhancement to IEEE 802.16 for the *licensed bands*. Moreover, multi-hop relay capabilities and functionalities of interoperable relay stations (RS) and base stations (MMR-BS) shall be specified. The specifications shall not require modifications to mobile stations (including subscriber stations) and thus shall be backward compatible with legacy IEEE 802.16/802.16e networks and mobile stations. The modification related to the MAC and OFDMA PHY specified in the 802.16-2004/802.16e-2005 standards shall be minimized.

1.3 General Requirement for 802.16j

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The overview of general requirements for 802.16j MMR-BS and RS are given in this section. Since we propose to consider 2-hop MMR networks mandatory and a general multi-hop (> 2) MMR networks optional (as specified in MMR-Cell requirement), the functional requirements to support a 2-hop only MMR network shall be considered mandatory while all additional requirements to support general multi-hop (>2) shall be considered optional. In addition, functional requirements used in all usage models shall be considered mandatory while the ones used in specific usage models shall be considered optional.

- MMR-cell
  - Hop count greater than or equal to 2 shall be supported. The specification shall consider 2-hop support mandatory while considering general multi-hop (>2) support optional.
  - The maximum number of associated RSs per MMR-BS shall be limited by the specification.

- MMR-Base Stations (MMR-BS)
  - The MMR-BS shall meet the same technical requirements with the 802.16-2004/802.16e-2005 base station with respect to supporting the MSs using OFDMA PHY. Whether these requirements are mandatory or optional shall depend on what they are for the corresponding requirement of the 802.16-2004/802.16e-2005 base station.
  - The major difference between MMR-BS and BS of 802.16-2004/802.16e-2005 is the MMR-BS capability to support relay stations.
  - With a centralized control mechanism, MMR network functions shall be entirely controlled by an MMR-BS and thus it needs to fully aware of its associated RSs
  - With a distributed control mechanism, MMR network functions shall be controlled cooperatively by the MMR-BS and by participating RSs.

- Relay Station (RS)
  - In order to ensure the backward compatibility, relay stations shall meet the same technical requirements as the 802.16-2004/802.16e-2005 base station with respect to access link transmission support, including the legacy PMP mode of medium sharing. Whether these requirements are mandatory or optional) shall depend on what they are for the corresponding requirement of the 802.16-2004/802.16e-2005 base station.
  - Relay stations shall not generate data traffic. However, they may generate control and management signaling to support proper relay operations.
  - The specification shall support RSs with various degrees of the complexity ranging from simple to complex.

- Mobile Station (MS)
  - Relay operations shall be transparent to mobile stations as specified in 802.16-2004/802.16e-2005.

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2. Functional Categories

The following table describes a list of system functional categories that are relevant to the IEEE 802.16j MMR network.

Label	Name	Description
CM	Configuration and Management	Requirements related to MMR network configuration, topology, multi-hop relay path, and how QoS is handled
NE	Network Entry	Requirements related to network entry including ranging, registration, authorization, etc.
BW	Bandwidth Request and Allocation	Requirements related to how an RS requests bandwidth for its transmission and how the bandwidth allocation is made
SCH	Scheduling	Requirements related to 802.16j MAC scheduling service
SMM	Subscriber Mode Management	Requirements related to subscriber mode management (such as sleep mode, idle mode, and active mode) for MSs in 802.16j
DATA	Data Delivery	Requirements related to data message forwarding and delivery
MM	Mobility Management	Requirements related to MS and MRS handovers
SEC	Security	Requirements related to MMR network security
PHY	OFDMA PHY	Requirements related to OFDMA PHY such as resource allocation, frame structure, duplexing, multiple antenna support, channel quality measurement, interference, synchronization, etc.

3. Functional Requirement Description

The tables in this section present the requirements details for each functional category defined in Section 2. The target of each functional requirement is shown in the third column of each table (i.e., MMR-BS and/or RS) along with its classification as either mandatory (M) or optional (O). Since the MMR-BS shall be backward compatible with the legacy IEEE 802.16/802.16e, only additional/modified requirements of the MMR-BS for MMR operations are discussed.

3.1 Configuration and Management

Number	**Name**	**Subject** (M) Mandatory (O) Optional	**Requirement**	**Informative Notes**
CM_1	**Capability Management**	MMR-BS(M) RS (M)	The specification shall allow MMR-BSs and RSs to negotiate	This requirement is to allow various level of

			the capabilities.	complexity with regard to RS functionalities.
CM_2	**MMR-Cell Topology**	MMR-BS(M)	The specification shall enable the MMR-BS automatic network topology learning including the status and quality of relay links with regards to its own MMR-cell	The MMR-BS shall maintain network topology within its own MMR-cell and control RSs within the MMR-cell
CM_3	**Neighbor Detection**	RS (O)	The specification shall enable the RS to detect its neighbor stations including the status and quality of radio link to each neighbor.	A neighbour station could be RS or MMR-BS.
CM_4	**Relay Path Setup**	MMR-BS(O) RS (O)	The specification shall define a mechanism to set up multi-hop (≥2) paths between an MMR-BS and RS and thus to enable data and/or control message forwarding.	There can be centralized and distributed approaches to determine a relay path.
CM_5	**Relay Path Metrics**	MMR-BS(O) RS (O)	The specification shall allow a flexible path selection mechanism to satisfy application requirements and mandatory traffic parameters depending on the service types specified in 802.16-2004/802.16e-2005.	
CM_6	**Multiple Relay Path**	MMR-BS(O) RS (O)	The specifications shall support the creation of more than one multi-hop path between an MMR-BS and MS.	
CM_7	**Relay Path Maintenance**	MMR-BS(O) RS (O)	The specification shall enable an RS and MMR-BS to automatically detect a path failure and then initiate a new route discovery process.	
CM_8	**Dynamic MMR-BS access**	MMR-BS (O) RS (O)	The specifications shall allow the association between MMR-BS and RS to be dynamically determined via a direct path or via multi-hop path.	This is useful for handover, load balancing, and fault tolerance.
CM_9	**Congestion Control**	MMR-BS(O) RS (O)	The specification shall enable RSs and MMR-BSs to prevent or promptly resolve network congestion.	
CM_10	**Connection Management**	MMR-BS(M) RS (O)	The specification shall define a mechanism to seamlessly support MS connections (i.e., CIDs) *via multi-hop*.	
CM_11	**Service Flow Managment**	MMR-BS(M) RS (TBD)	The specification shall define a mechanism to establish service flows (i.e., SFIDs) *via multi-hop*.	Support all existing service classes as defined in 802.16e-2005.
CM_12	**BS/RS Control**	MMR-BS(M) RS (M)	The spec shall define a mechanism for MMR-BS to control and manage RS.	

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Comment [h1]: CM_2 and CM_12 are merged to "RS control" in C80216j-06_050r2

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Comment [h3]: CM_4, CM_5, and CM_7 are merged to "Relay Path Selection" in C80216j-06_050r2.

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CM_13	**Dynamic Frequency Assignment**	MMR-BS(O) RS (O)	The specification shall enable MMR-BS and/or RS to dynamically select the best available channels in order to maximize throughput and to minimize interference.	A static frequency assignment shall be used if this dynamic scheme is not supported.
CM_14	**Location Information**	MMR-BS (O) RS (O)	The specification shall support RS to perform location update	

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3.2 Network Entry

Number	Name	Subject (M) Mandatory (O) Optional	Requirement	Informative Notes
NE_1	**RS Network Entry**	MMR-BS(M) RS (M)	The specification shall enable an RS to enter into an MMR-cell and obtain service from MMR-BS/RS.	This process can be divided into many sub-processes such as DL synchronization, ranging, capabilities exchange, authorization, registration and etc.
NE_2	**MS Network Entry Support**	RS (M)	The specifications shall enable the RS to support the MS with network entry.	This process can be divided into many sub-processes such as DL synchronization, ranging, capabilities exchange, authorization, registration and etc.

3.3 Bandwidth Request and allocation mechanisms

Number	Name	Subject (M) Mandatory (O) Optional	Requirement	Informative Notes
BW_1	**Bandwidth Request for RS**	MMR-BS(M) RS (O)	The specification shall define a scheme for an RS to request bandwidth allocation for its uplink and downlink transmission.	Depending on where scheduling is performed, an RS may not need to request downlink bandwidth. The requests can be for forwarding messages generated by MSs or control messages generated by RS. 6.3.10.3 and 8.4.7 of 802.16-2004/802.16e-2005 can be used as a reference for contention

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				bandwidth request.
BW_2	**Bandwidth Allocation Announcement**	MMR-BS(M) RS (O)	The specification shall define a mechanism by which RS/MMR-BS inform their downstream RSs of bandwidth allocation.	For the access link, DL MAPs and UL MAPs are used to broadcast bandwidth allocations and MAP IEs are used to describe the allocations in detail.

3.4 Scheduling

Number	Name	Subject (M) Mandatory (O) Optional	Requirement	Informative Notes
SCH_1	**Scheduling**	MMR-BS (M) RS (M)	The specification shall provide signaling to support MAC scheduling of data and control message transmissions on relay and access links.	Scheduling may be centralized, distributed, or a hybrid thereof.
SCH_2	**QoS Traffic Parameters**	MMR-BS (M) RS (TBD)	The specification shall ensure that the scheduling supports QoS over multi-hop paths. QoS is specified by traffic parameter values of the service types defined in 802.16e-2005.	The scheduling to support QoS traffic parameters may be centralized, distributed, or a hybrid thereof.

Comment [h10]: SCH_2 and CM_11 are merged to "QoS Support" in C80216j-06_050r2.

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3.5 Subscriber Mode Management

Number	Name	Subject (M) Mandatory (O) Optional	Requirement	Informative Notes
SMM_1	**Power saving Class and Operation Parameters**	MMR-BS(O) RS(O)	The specification shall enable MMR-BS and RS to be aware of the power saving class and operation parameters associated with MSs.	This requirement is related to how sleep/idle mode parameters are negotiated and exchanged between MS, RS and MMR-BS.
SMM_2	**Sleep/Idle Mode Aware Scheduling**	MMR-BS(O) RS(O)	Both centralized and decentralized MAC scheduling function shall consider the parameters of sleep/idle mode operations for MSs, and buffer messages on MMR-BS and RS.	

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3.6 Data Delivery

Number	Name	Subject	Requirement	Informative Notes

		(M) Mandatory (O) Optional		
DATA_1	**MAC PDU Processing**	RS (TBD)	The specification shall enable relay station MAC PDU configuration and processing.	
DATA_2	**Unicast Data Delivery**	RS (M)	The specification shall support unicast data delivery across the relay stations.	
DATA_3	**Multicast Data Delivery**	MMR-BS(O) RS (O)	The specification shall support multicast/broadcast data delivery across the relay stations	
DATA_4	**ARQ Processing**	MMR-BS(O) RS (O)	The specification shall define a mechanism which supports mobile station's ARQ operation via multi-hop relay.	
DATA_5	**HARQ Processing**	MMR-BS(O) RS (O)	The specification shall define a mechanism which supports mobile station's HARQ operation via multi-hop relay.	
DATA_6	**Cooperative Relay**	RS (O)	The specification shall enable the RS to participate in cooperative relay for an MS and/or RS	

3.7 Mobility Management

Number	Name	Subject (M) Mandatory (O) Optional	Requirement	Informative Notes
MM_1	**MS Handover Support**	MMR-BS(M) RS (M)	The specification shall ensure that MS handover support via multi-hop topology does not require modification to MS.	This requirement is to provide backward compatibility. There shall be no visible performance degradation during the intra-cell handover.
MM_2	**Mobile RS (MRS) Handover**	MMR-BS (O) RS (O)	The specification shall support RS with mobility and its subordinate MSs.	
MM_3	**Handover Decision for Subordinates Stations**	MMR-BS(O) RS(O)	The specification shall allow the handover decision originated by a serving RS or MMR-BS on behalf of moving stations.	
MM_4	**Fast Serving Station Switch**	RS (O)	The specification shall enable the RS to participate in Fast Serving Station Switching for an MS and/or MRS	
MM_5	**Macro Diversity Handover**	RS (O)	The specification shall enable the RS to participate in Macro Diversity Handover for an MS and/or MRS	
MM_6	**Mobile RS (MRS)**	MMR-BS (O) RS (O)	The specification shall enable an MRS to scan candidate stations.	Candidate stations can assist MRS to

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MM_7	**Network Topology Advertisement**	MMR-BS (M) RS (TBD)	The specification shall enable the MMR-BS, RS broadcast/re-broadcast information about the network topology. This message will provide MS channel information of neighboring MMR-BS/RS as well as legacy BS without requiring any modification to MS.	6.3.22.1.1 of 802.16e-2005 can be used as a reference for network topology advertisement.
MM_8	**MRS Handover Decision**	RS(O)	The specification shall allow the MRS to request a handover for itself.	

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3.8 Security

Number	**Name**	**Subject** (M) Mandatory (O) Optional	**Requirement**	**Informative Notes**
SEC_1	**Relay Security**	MMR-BS(M), RS(M)	The specification shall define security mechanisms to ensure security between an MMR-BS and RS, between RSs, and between an RS and MS.	For RS to perform as a forwarder, the security architecture in 802.16-2004/ 802.16e-2005 only has to be extended to support security between MMR-BS and RS.
SEC_2	**Secure Message Exchange**	MMR-BS(M) RS (O)	The specification shall define a mechanism to exchange secure data/management messages	
SEC_3	**MMR-BS Authentication**	MMR-BS (O) RS(O)	The specification shall permit the RS to authenticate the MMR-BS when it joins an MMR network.	The relay stations may need to authenticate the network when they are joining before sending traffic. i.e. not all MMR-BS can be trusted.

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Comment [h13]: SEC_2 was removed in 80216j-06_050r2.

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3.9 OFDMA PHY

All PHY functional requirements described in this section refer to relay links and the specification shall conform to OFDMA PHY defined in 802.16-2004/802.16e-2005 unless stated otherwise.

Number	**Name**	**Subject** (M) Mandatory (O) Optional	**Requirement**	**Informative Notes**
PHY_1	**Flexible Radio Resource Assignment**	MMR-BS(M) RS (M)	The specification shall support various form of radio resource assignment: sharing channels	

			between access links and relay links, sharing channels between multiple relay links, using different channels for different links, etc.	
PHY_2	**LOS and NLOS**	MMR-BS(M) RS (M)	The specification shall support both LOS and NLOS relay links.	
PHY_3	**RS Emissions**	RS (M)	The specification shall ensure RS emissions to be sufficiently low so that it is compatible with mobile stations operating nearby on adjacent channels	The transmissions of the RS must not degrade the performance of other mobiles using adjacent channels and other system BS
PHY_4	**RS Susceptibility**	RS (M)	The specification shall ensure that RS's receiver susceptibility sufficiently low and thus it is compatible with the emissions of mobile stations operating nearby on adjacent channels	The RS operation should not be affected by transmissions from MS operating nearby using adjacent channels and other system BS
PHY_5	**PHY Parameters**	MMR-BS(O) RS(O)	The specification shall allow an MMR-BS or RS to be configured to use different PHY parameters on the different RF frequency band.	
PHY_6	**Duplexing Modes**	MMR-BS (M) RS (M)	The specification shall support either TDD or FDD for relay links.	H-FDD support is optional
PHY_7	**Multi-hop Frame Structure**	MMR-BS (M) RS (M)	The specification shall define a frame structure for relay links which support multi-hop (≥2). The frame structure shall not require the modification of 802.16e MS functionalities.	It is desirable that the overhead shall not significantly increase with the hop count between an MMR-BS and MS.
PHY_8	**Preamble**	RS (TBD)	The specification shall support the preamble transmission by RS.	
PHY_9	**Transmission Parameter Synchronization**	MMR-BS(M) RS (M)	The RS shall be able to synchronize its time/frequency/power for the downlink and uplink to the upstream neighbor station.	The ranging process can be a means to achieve this.
PHY_10	**Higher Efficiency MCS**	MMR-BS (O) RS(O)	The specification shall allow higher modulation or coding schemes on relay links to support high capacity.	An RS may use different coding scheme for relay link from the one used for access link.
PHY_11	**Multiple Antenna Support**	MMR-BS (O) RS (O)	The specification shall allow the use of multiple antennae to enhance spectral efficiency of the system or extend the coverage.	This includes MIMO, beamforming, transmit diversity, etc.
PHY_12	**Channel**	RS (M)	The specification shall enable the	Channel quality

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	Quality Measurement		RS to make channel quality measurements for its received signal.	measurements can be SINR and RSSI.
PHY_13	**Interference**	RS (O)	The specification shall enable RSs to distinguish inter MMR-cell interference from intra MMR-cell.	This feature can be used to support efficient radio resource sharing in an MMR-cell and further to support SDMA.
PHY_14	**CQICH (O)**	RS (O)	The specification shall enable the RS to allocate a CQICH subchannel to support fast feedback quality report and AMC	

Comment [h15]: PHY_13 needs more discussions.

Appendix A

Most of the terms defined in Appendix A. are drawn from the contributions IEEE C80216j-06_041 [3] and IEEE C80216j-06_019 [4]. We have copied the most relevant terms from those documents here for convenience. The terminologies in the harmonized contribution IEEE C80216j-06_041 [3] shall override the ones in IEEE C80216j-06_019 [4] if there is any discrepancy between them.

access link: An 802.16 radio link that originates or terminates at an MS. The access link can be uplink or downlink.

access traffic: traffic traveling over an access link

candidate station: A potential serving station for a given MS during the next handover. A candidate can be an RS, BS, or MMR-BS (i.e., candidate RS, candidate BS or candidate MMR-BS).

downstream: In the direction of an MS following the MMR path originating at an MMR-BS

fast serving station switching (FSSS): Serving station switching with which an MS can change its serving station from frame to frame depending on the serving station selection mechanism. A serving station can be an RS, BS, or MMR-BS

MMR base station (MMR-BS): A base station that is compliant with amendments IEEE 802.16j through IEEE 802.16e-2005, which has extended functionality to support MMR as defined in 802.16j.

MMR-cell: The geographic area composed of the MMR-BS cell and all of its subordinate RS cells.

MMR traffic: Traffic traveling over a relay link

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mobile multihop relay (MMR): The concept of relaying user data and possibly control information between an MMR base station and an IEEE Standard 802.16 compliant mobile station through one or more relay stations.

neighbor station (NS): A station that is within one-hop communication range of the station of interest

relay link: An 802.16j radio link between an MMR-BS and an RS or between a pair of RSs. This can be a relay uplink or downlink.

upstream: In the direction of an MMR-BS following the MMR path originating at an MS

References

[1] Draft P802.16j PAR and Five Criteria, IEEE 802.16mmr-06/002r1

[2] IEEE802 Tutorial: 802.16 Mobile Multihop Relay, IEEE 802.16mmr-06/006

[3] Harmonized definitions and terminology for Mobile Multihop Relay, IEEE C80216j-06_041

[4] Definition of terminology used in Mobile Multihop Relay, IEEE C80216j-06_019

[5] IEEE 802.16-2004 standard

[6] IEEE 802.16e-2005 standard