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802.16n Amendment Working Draft

NOTE- The editing instructions are shown in ***bold italic***. Four editing instructions are used: ***change***, ***delete***, ***insert***, and ***replace***. ***Change*** is used to make small corrections in existing text or tables. The editing instruction specifies the location of the change and describes what is being changed by using strike through (to remove old material) and underscore (to add new material). ***Delete*** removes existing material. ***Insert*** adds new material without disturbing the existing material. Insertions may require renumbering. If so, renumbering instructions are given in the editing instruction. ***Replace*** is used to make large changes in existing text, subclauses, tables, or figures by removing existing material and replacing it with new material. New materials to be added to existing standard (in Clauses 1 to 16) are blue underlined. New materials under Clause 17 are in black and are not underlined.

1. Overview

1.1 Scope

1.2 Purpose

2. Normative references

3. Definitions

[Insert the following definitions (renumbering may be required):]

3.148 Degraded Network: The failure of one or more 802.16 network infrastructure nodes or network connectivity.

3.149 Robustness: The capability of the network to withstand and automatically recover from degradation to provide the required availability to support mission critical applications (essential to the core function of society and the economy) including recovery from a single point of failure.

3.150 Mobile Base Station: A base station which is capable of maintaining service while moving.

3.151 Radio Path Redundancy: The ability to provide alternative paths between base stations, relay stations, and subscriber stations.

3.152 HR-MS: A subscriber station that complies with the requirements for subscriber stations in high reliable network.

3.153 HR-BS: A base station that complies with the requirements for base stations in high reliable network.

3.154 HR-RS: A relay that complies with the requirements for relays in high reliable network.

3.155 HR-Network: A network whose stations comply with their respective HR requirements.

3.156 HR-station: An HR-MS, HR-BS, or HR-RS.

3.157 Infrastructure station: An HR-BS or HR-RS.

3.158 Directly Associated: An HR-MS is directly associated with an infrastructure station if it is effectively controlled directly by it.

3.159 Indirectly Associated: An HR-MS is indirectly associated with an infrastructure station if it is effectively controlled by it through a forwarding HR-MS.

3.160 Coexistence: Coexistence is a state by which multiple wireless communications systems in same vicinity share a same radio frequency channel while minimizing harmful interference to each other by appropriate measures.

3.161 Self-coexistence: In HR network, self-coexistence is coexistence of multiple HR cells.

3.162 Self-coexistence mode: Self-coexistence mode is an operation mode of HR network, in which multiple HR cells share the same frequency channel in time.

4. Abbreviations and acronyms

[Insert the following abbreviations:]

HR	High Reliability
PPDR	Public Protection and Disaster Relief
SPOF	Single Point of Failure

5. Service Specific CS

6. MAC common part sublayer

7. Security sublayer

8. Physical layer (PHY)

8.4 WirelessMAN-OFDMA PHY

8.4.1 Introduction

[Insert the following sentence into section 8.4.1 on Page 694 at the end of 2nd paragraph:]

The OFDMA PHY may support the VHF mode specified in 17.2.12.

8.4.3 OFDMA basic terms definition

8.4.3.1 Slot and data region

[Change the 2nd and 3rd bullet points in Section 8.4.3.1as indicated:]

— For DL PUSC (defined in 8.4.6.1.2.1), one slot is one subchannel by two OFDMA symbols. For VHF mode DL PUSC, one slot is one subchannel by four OFDMA symbols.
— For UL PUSC (defined in 8.4.6.2.1 and 8.4.6.2.5) and for DL TUSC1 and TUSC2 (defined in 8.4.6.1.2.4 and 8.4.6.1.2.5), one slot is one subchannel by three OFDMA symbols. For VHF mode UL PUSC, one slot is one subchannel by seven OFDMA symbols.

8.4.4.3 OFDMA Frame Parameters and Operations

[Insert the following text at the end of Section 8.4.4.3:]

In VHF mode, subcarrier allocation scheme of PUSC (defined in 8.4.6.1.2.1.1 and 8.4.6.2.2) is used for both UL and DL and duplex method is TDD, and MIMO, STC scheme are not used.

8.4.4.4 DL frame prefix

[Insert the following text at the end of Section 8.4.4.4:]

For VHF mode, CC encoding used on DL-MAP is selected as “Coding_Indication” from DL frame prefix format shown in Table 314. The FFT size of 1024 is selected from Table 315.

8.4.6 OFDMA subcarrier allocations

[Insert the following text at the end of Section 8.4.6:]

In VHF mode, sampling factor n is 8/7 for the channel bandwidth of 5 MHz and also subcarrier allocation scheme of PUSC (defined in 8.4.6.1.2.1 and 8.4.6.2.5) is used for both UL and DL.

8.4.6.1.2.1 Symbol structure for PUSC

[Insert the following text at the end of Section 8.4.6.1.2.1:]

For VHF mode, the symbol is first divided into basic tiles (as defined in Figure 247a) and zero carriers are allocated. Pilots and data carriers are allocated within each tile. Table 442a summaries the parameters of the symbol structure under this PHY mode.

A slot in the DL of VHF mode is composed of **four (4)** OFDMA symbols and one subchannel. Within each slot, there are **48** data subcarriers and **16** fixed-location pilots as shown in Table 247a. The subchannel is constructed from **four(4)** DL tiles. Each tile has four successive active subcarriers, and its configuration is illustrated in Figure 247a.

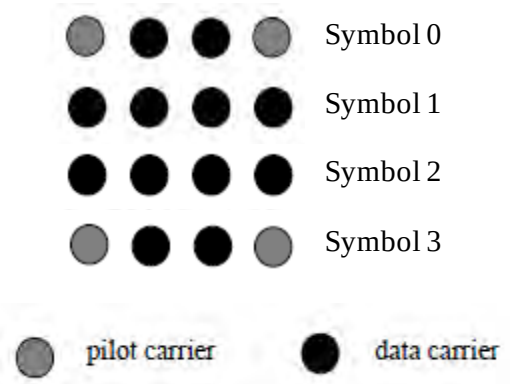

Figure 247a—Description of a DL tile in VHF Mode

8.4.6.2.1 Symbol structure for subchannel (PUSC)

[Insert the following text at the end of Section 8.4.6.2.1:]

For VHF mode, a slot in the UL is composed of **seven (7)** OFDMA symbols and one subchannel. Within each slot, there are **48** data subcarriers and 8 fixed-location pilots as shown in Table 249a. The subchannel is constructed from **two(2)** UL tiles. Each tile has four successive active subcarriers, and its configuration is illustrated in Figure 249a.

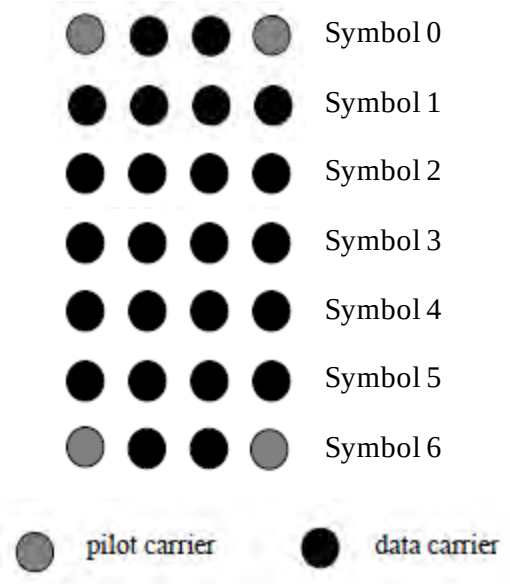

Figure 249a—Description of an UL tile in PHY Mode specified for HR-Network

8.4.9.3 Interleaving

[Insert the following text at Section 8.4.9.3 on Page 1061 before the last 2nd paragraph:]

For VHF mode, the first and second permutation follows the equations (121) and (122), respectively with d=18.

10. Parameters and constants

11. TLV encodings

16. WirelessMAN-Advanced Air Interface

16.1 Introduction

16.2 Medium access control

16.2.1 Addressing

16.2.1.3 Addressing to support machine to machine application

16.2.2 MAC PDU formats

16.2.3 MAC Control messages

[Change Table 677 as indicated (renumbering may be required):]

Table 677 – MAC control messages

No.	Functional Areas	Message names	Message description	Secuirty	Connection
71	Backbone Enable	BBE-REQ	Backbone Enable Request		Unicast
72	Backbone Enable	BBE-RSP	Backbone Enable Response		Unicast
73	Backbone Disable	BBD-REQ	Backbone Disable Request		Unicast
74	Backbone Disable	BBD-RSP	Backbone Disable Response		Unicast
75	Backbone Enable	BBE-CMD	Backbone Enable Command		Broadcast
76	Backbone Disable	BBD-CMD	Backbone Disable Command		Broadcast

[Insert the following new sections (renumbering may be required):]

16.2.3.64 BBE-REQ

An HR-BS transmits a BBE-REQ message to notify HR-MSs of backbone connection availability on unicast control connection.

16.2.3.65 BBE-RSP

An HR-MS transmits a BBE-RSP message in response to a received BBE-REQ.

16.2.3.66 BBD-REQ

An HR-BS transmits a BBD-REQ message to notify HR-MSs of backbone connection unavailability on unicast control connection.

16.2.3.67 BBD-RSP

An HR-MS transmits a BBD-RSP message in response to a received BBD-REQ.

16.2.3.68 BBE-CMD

An HR-BS transmits a BBE-CMD message to broadcast backbone connection availability.

16.2.3.69 BBD-CMD

An HR-BS transmits a BBD-CMD message to broadcast backbone connection unavailability.

[Change Table 678 in section 16.2.3.1 as indicated:]

Table 678.—AAI-RNG-REQ message Field Description

Field	Size (bits)	Value/Description	Condition
Ranging Purpose Indication	4	0b0000 = Initial network entry 0b0001 = HO reentry 0b0010 = Network reentry from idle mode 0b0011 = Idle mode location update 0b0100 = DCR mode extension 0b0101 = Emergency call setup (e.g., E911) 0b0110 = Location update for updating service flow management encodings of E-MBS flows 0b0111 = Location update for transition to DCR mode from idle mode 0b1000 = Reentry from DCR mode, coverage loss or detection of different ABS restart count. 0b1001 = Network reentry from a Legacy BS 0b1010 = Zone switch to MZONE from LZONE 0b1011 = Location update due to power down.	-

		0b1100 = Interference mitigation request to a CSG Femto ABS when experiencing interference from the CSG Femto ABS 0b1101 = NS/EP call setup ~~0b1110–0b1111 = reserved~~ 0b1110 = HR multicast service flow update 0b1111 = reserved	
…	…	…	…

16.2.4 Construction and Transmission of MAC PDUs

16.2.5 AAI Security

16.2.5.5 Security mechanisms for machine to machine application

16.2.6 MAC HO procedures

16.2.7 Persistent Scheduling in the Advanced Air Interface

16.2.8 Multicarrier operation

16.2.9 Group Resource Allocation

16.2.10 Connection Management

16.2.11 Bandwidth Request and Allocation Mechanism

16.2.12 Quality of Service (QoS)

16.2.13 ARQ mechanism

16.2.14 HARQ functions

16.2.15 Network entry and initialization

16.2.15.7 Network entry and initialization for machine to machine operation

16.2.16 Periodic ranging

16.2.17 Sleep mode

16.2.18 Idle mode

16.2.19 Deregistration with context retention (DCR) mode

16.2.20 Co-located coexistence (CLC)

16.2.21 Interference mitigation mechanism

16.2.22 MAC control reliability

16.2.23 Power management for active mode

16.2.24 Update of S-SFH IEs

16.2.25 Short Message Service

16.2.25.1 Small burst transmission for machine to machine application

16.2.26 Coverage Loss Detection and Recovery from Coverage Loss

16.2.27 AMS deregistration

16.2.28 Support for Multicast Service

16.2.28.4 Multicast operation for machine to machine application

16.2.29 MAC Support for M2M Application

16.2.29.1 Introduction

16.2.29.2 Addressing

16.2.29.3 Security

16.2.29.4 Network (Re-)entry

16.2.29.5 Idle Mode

16.2.29.6 Support of Multicast Service

16.2.29.7 Support of M2M short packet transmission

16.2.29.8 Group Resource Allocation

16.2.29.9 Device Collaboration

16.3 Physical layer

[Change section 16.3.5.5.2.4 as indicated:]

16.3.5.5.2.4 Assignment A-MAP IE

Table 842 describes Assignment A-MAP IE Types.

Table 842 – Assignment A-MAP IE Types

A-MAP IE Type	Usage	Property
0b0000	DL Basic Assignment A-MAP IE	Unicast
0b0001	UL Basic Assignment A-MAP IE	Unicast
0b0010	DL Subband Assignment A-MAP IE	Unicast
0b0011	UL Subband Assignment A-MAP IE	Unicast
0b0100	Feedback Allocation A-MAP IE	Unicast
0b0101	UL Sounding Command A-MAP IE	Unicast
0b0110	CDMA Allocation A-MAP IE	Unicast
0b0111	DL Persistent Allocation A-	Unicast

	MAP IE	
0b1000	UL Persistent Allocation A-MAP IE	Unicast
0b1001	Group Resource Allocation A-MAP IE	Multicast
0b1010	Feedback Polling A-MAP IE	Unicast
0b1011	BR-ACK A-MAP IE	Multicast
0b1100	Broadcast Assignment A-MAP IE	Broadcast/Multicast
0b1101	~~Reserved~~ HR-Multicast DL Assignment A-MAP IE	~~NA.~~ Multicast
0b1110	Reserved	NA.
0b1111	Extended Assignment A-MAP IE	NA.

CRC Mask

A 16-bit CRC is generated based on the randomized contents of assignment A-MAP IE and is masked by 16-bit CRC mask using the bitwise XOR operation.

The 16-bit masked CRC is constructed using a 1 bit masking prefix, a 3 bit message type indicator, and 12 bit Masking Code as described in Table 843.

Table 843 – Description of CRC Mask

Masking Prefix (1 bit MSB)	**Remaining 15 bit LSBs**	
0b0	*Type Indicator*	*Masking Code*
	0b000	12 bit STID or TSTID
	0b001	Refer to Table 844
	0b010	Refer to Table 845
0b1	15 bit RA-ID: The RA-ID is derived from the AMS' random access attributes (i.e., superframe number (LSB 5bits), frame_index (2 bits), preamble code index for ranging or BR (6 bits) and opportunity index for ranging or BR (2 bits)) as defined below: RA-ID = (LSB 5bits of superframe number | frame_index | preamble_code_index | opportunity_index)	

……

Table 845 – Description of Masking Code for type indicator 010

Decimal Value	**Description**
4095	Used to mask Broadcast A-MAP IE for multicast assignment
Others	~~Reserved~~ 12 bit MGID is used to make HR-Multicast DL Assignment A-MAP IE for high reliable multicast assignment

16.3.11 Global Values
16.4 Support for Femto ABS
16.4.1 General description
16.4.2 Femto base station subscription types
16.4.3 Femto ABS state diagram
16.4.4 PHY and MAC level identifier
16.4.4.1 PHY level cell identifier
16.4.4.2 CSG white list
16.4.5 Femto ABS initialization and de-attachment
16.4.6 Network synchronization
16.4.7 Network entry
16.4.8 Handover (HO)
16.4.9 Idle mode
16.4.10 Low-duty operation mode
16.4.11 Interference avoidance and interference mitigation
16.4.12 Power control
16.4.13 Femto ABS reliability
16.5 Multi-BS MIMO
16.6 Support for Relay
16.6.1 Relay Modes and General Description
16.6.2 Medium access control
16.6.2.1 Addressing
16.6.2.2 MAC PDU Formats
16.6.2.3 Construction and Transmission of MPDUs
16.6.2.4 Security
16.6.2.5 Handover
16.6.2.6 Scheduling and QoS
16.6.2.7 Bandwidth Request and Grant Management
16.6.2.8 ARQ
16.6.2.9 HARQ
16.6.2.10 Network Entry

16.6.2.11 Ranging
16.6.2.12 Sleep Mode
16.6.2.13 Idle Mode
16.6.2.14 ARS Configuration
16.6.2.15 ARS De-registration
16.6.2.16 Update of SFH
16.6.3 Physical Layer for TTR relay mode
16.6.3.1 Basic frame structure supporting ARS
16.6.3.2 Frame structure
16.6.3.3 Relay Downlink PHY Structure
16.6.3.4 Downlink Control Structure
16.6.3.5 Relay Uplink physical structure
16.6.3.6 Uplink Control Structure
16.6.4 Physical Layer for STR relay mode
16.7 Support for Self-organization
16.8 Support for Location Based Services (LBS)
16.9 Support for Enhanced Multicast Broadcast Service
16.10 Support for Advanced Air Interface in LZone
16.10.11 Global Values

[Insert the following clause:]

17. WirelessMAN-High Reliability Network

17.1 Overview

17.1.1 Operating frequencies

17.1.2 Operating bandwidths

17.1.3 Duplex

17.1.4 Backward compatibility

17.2 WirelessMAN HR-OFDMA air interface

17.2.1 Multi-mode operation

17.2.1.1 Relay function for HR-BS

An HR-BS (affected HR-BS) may operate as a relay station to communicate with another HR-BS (serving HR-BS) that has connection to backhaul.

An HR-BS acting as RS mode operates in either TTR mode or STR mode.

17.2.1.1.1 STR mode for HR-BS acting as HR-RS

To support STR mode, the affected HR-BS maintains base station functionality.

The procedures for RS mode change consist of following activities:

a) establish a relay link with a serving HR-BS

b) if necessary, inform some subordinate stations to perform handover

c) if necessary, reconfigure the physical frame and commence operation in relay mode

17.2.1.1.2 TTR mode for HR-BS acting as HR-RS

To support TTR mode, the affected HR-BS can maintain connectivity with subordinate HR-RS. How to maintain is FFS.

The procedures for RS mode change consist of following activities:

a) establish a relay link with a serving HR-BS

b) if necessary, inform some subordinate stations to perform handover

c) if necessary, reconfigure the physical frame and commence operation in relay mode

17.2.1.2 Relay function for HR-MS

An HR-MS may operate as an HR-RS to provide connectivity for multiple out-of-coverage HR-MSs. During basic capability negotiation within network entry, an HR-MS that is capable of role change to HR-RS shall report such capability to the super-ordinate HR-BS/HR-RS.

While operating as HR-RS, the station may maintain certain HR-MS functionalities. A mode switch to HR-RS shall be commanded by its superordinate HR-BS.

If the HR-MS release its role from the relay mode, HR-MS may perform handover to the any infrastructure station.

17.2.1.3 Base station function for HR-MS

An HR-MS may operate as an HR-BS to provide connectivity for itself and other HR-MSs. During basic capability negotiation within network entry, an HR-MS that is capable of role change to HR-BS shall report such capability to the super-ordinate HR-BS/HR-RS.

While operating as an HR-BS, the station may maintain certain HR-MS functionalities. A mode switch to HR-BS may be initiated by the HR-MS itself or may be directed by the superordinate HR-BS of the HR-MS.

17.2.2 Direct communication between HR-MSs

17.2.2.1 General Description

In HR-MS direct communication, the two communicating HR-MSs are the source and the sink of data. The data packets are passed from upper layers to MAC at the source HR-MS and back to upper layers at the sink HR-MS. Data packets are exchanged between the two HR-MSs directly or by passing through another HR-MS.

HR-MS direct communication is applicable when 1) the two HR-MSs are in coverage of and are directly associated to an HR infrastructure station; 2) one HR-MS is in coverage of and directly associated to an HR infrastructure station, while the other HR-MS is out of coverage of any HR infrastructure stations; 3) the two HR-MSs are out of coverage of any HR infrastructure stations.

Resource for HR-MS direct communication can be allocated by the HR infrastructure station for cases (1) and (2).

For case-3, direct communications between HR-MSs shall satisfies:

- The operation of HR-MSs shall not interfere with any existing infrastructure stations. When HR-MS cannot receive any BS preamble from any infrastructure station and HR-MS direct communication without infrastructure is permitted by device configuration, HR-MSs are allowed to communicate with each other in the same band without getting permission from infrastructure stations.
- A Coordinator is selected for the coordination of transmission among HR-MSs. Until a coordinator is selected, an HR-MS is only allowed to transmit signals necessary to enable coordinator selection. To avoid collisions among HR-MSs in coordinator selection, the HR-MS follow a collision avoidance procedure. The procedure is

defined in 17.2.2.5.

- A coordinator shall function as a simplified HR-BS except it may not support handover. How to select a coordinator among HR-MSs shall follow the operation described in TBD.
- A coordinator supports the following topologies:
    1. HR-MS linked to the coordinator and the pair is the source and sink of data. This topology is implemented through the local source and sink capability of the HR-MS.
    2. Two HR-MS linked to the coordinator and the two HR-MS are the source and sink of data. This topology is implemented through the local forwarding capability of the HR-BS.
    3. A forwarding HR-MS forwards data of a forwarded HR-MS to the coordinator. This topology is implemented through the HR-BS capability to support HR-MS forwarding operation.
    4. Two HR-MS are linked (DC) and are the source and sink of data to each other under the control of the coordinator. This topology is implemented through the HR-BS ability to support DC between its subordinates.
- The coordinator and any HR-MS that are communicating through the coordinator shall continue cell search operation and shall cease DC operation as soon as the criteria for DC and prevention of interference above are not met.

17.2.2.2 Frame Structure and Resource Allocation

Resources for HR-MS Direct Communications and HR-MS Forwarding to Network shall be scheduled by the serving HR-BS/RS when one exists. Serving HR-BS/RS can schedule direct communication in an on-demand and dynamic manner, and can multiplex this with transmissions between HR-MS and HR-BS / HR-RS.

To optimize the signaling and switching cost and improve QoS provisioning to HR-MS direct communication, serving HR-BS / HR-RS can schedule resource for DC/FTN zone for multiplexing DC/FTN transmissions. An HR-MS DC / FTN Zone is an area of continuous OFDMA resources in time and logical subchannels or resource units. The size and location of DC/FTN zone is dynamically or semi-stationary determined by the serving HR-BS.

When an infrastructure node doesn’t exist, one of the HR-MS shall fulfill this coordinating role. It is understood that the coordinating HR-MS needs to take on some of the functionality of a HR-BS and may also require new functionality.

All resource scheduling shall be dynamically conveyed through MAP or DL control messages from serving HR-BS/RS or a coordinating HR-MS. In the case of HR-MS Forwarding to Network, the scheduling messages shall be forwarded by the forwarding HR-MS.

Random access channels may be used for bandwidth request. For case-1, bandwidth request are sent directly to the serving HR-BS /HR-RS. For case 2, bandwidth requests are forwarded by the forwarding HR-MS.

17.2.2.3 Synchronization

Synchronization between HR-MSs is classified into two levels:

- The frame-level (first level) should allow HR-MSs to share a common understanding of frame and/or superframe timing and configuration.
- The symbol-level (second level) should allow reliable (i.e. received within cyclic prefix) bi-directional transmissions between HR-MSs.

Synchronization mechanisms are specified for three different use cases as follows.

17.2.2.3.1 Use case 1: Both HR-MSs are within the coverage of HR-BS/RS

- The first level of synchronization shall be maintained by common DL signaling (i.e. preambles, FCH, MAP…) from HR-BS/RS.
- The second level of synchronization can be achieved by HR-MSs exchanging ranging signals.

The following synchronization mechanisms are specifically designed for the case when HR-MS DC and FTN are scheduled in UL area of a frame.

Frame-level Synchronization:

When both HR-MSs are able to receive preambles and DL control signals from HR-BS/HR-RS, they shall use these to achieve frame-level synchronization (with respect to HR-BS/HR-RS and between themselves). When both HR-MSs involved in DC or FTN are within the coverage of HR-BS/HR-RS, frame-level synchronization means the HR-MSs acquire DL synchronization with the serving HR-BS/HR-RS and are able to achieve system configuration and control messages.

Symbol-level Synchronization:

When the HR-MS/HR-MS direct link is scheduled in a UL area of a frame, the transmitting HR-MS shall follow the same timing advance as has been adjusted and agreed with the serving HR-BS/HR-RS. This means the transmitting HR-MS shall time its

direct transmissions as if these are normal UL transmissions toward the serving HR-BS/HR-RS.

It is the responsibility of the receiving HR-MS to adjust its receive timing to match the time of arrival (TOA) of the signal transmitted by the other HR-MS. This time adjustment shall be achieved by the serving HR-BS/HR-RS scheduling the HR-MSs to transmit ranging sequences to each other. Based on a received ranging sequence, an HR-MS can estimate and correct its time offset with the transmitting HR-MS. To facilitate this process, the serving HR-BS/HR-RS shall assign dedicated ranging sequences and ranging channels in UL area of a frame for HR-MS/HR-MS direct ranging.

To enhance bi-directional communication between HR-MSs, the serving HR-BS/HR-RS can allocate ranging resources to both involved HR-MSs in a single assignment. This allows the receiving HR-MS to transmit back a ranging sequence right after successfully processing the ranging sequence transmitted by the other HR-MS.

17.2.2.3.2 Use case 2: one HR-MS is inside and the other is outside the coverage of HR-BS/RS

- The first level of synchronization shall be achieved by the inside-of-coverage HR-MS transmitting preamble and in some cases network configuration information toward the outside-of-coverage HR-MS. The locations of these control signals are TBD. HR-MS that are associated with an HR-BS transmit preambles at known locations. The preamble location and conditions for transmission are TBD.

- The second level of synchronization can be achieved by HR-MSs exchanging ranging signals.

The following synchronization mechanisms are specifically designed for the case when HR-MS DC and FTN are scheduled in UL area of a frame.

Frame-level Synchronization:

When two HR-MSs need to achieve frame-level synchronization and only one of them is within the coverage of and registered with an HR-BS/HR-RS, the registered HR-MS shall first acquires DL synchronization with the serving HR-BS/HR-RS (based on preambles and control messages from the serving HR-BS/HR-RS). The registered HR-MS shall subsequently broadcast preambles and possibly network configuration information (NCI) for the outside-of-coverage HR-MS to co-synchronize.

The registered HR-MS shall transmit preambles either at the first OFDMA symbol or the last OFDMA symbol of the frame. The NCI shall be transmitted in an UL area. The location of the NCI, relative to the transmitted preambles, shall be determinable by the outside-of-coverage HR-MS.

Symbol-level Synchronization:

Using the preambles and NCI transmitted by the inside-of-coverage HR-MS, the outside-of-coverage HR-MS shall adjust its timing to receive messages transmitted from the inside-of-coverage HR-MS. To further improve synchronization in this direction, the inside-of-coverage HR-MS can transmit ranging signal toward the outside-of-coverage HR-MS so that this node can estimate and correct its time/frequency offsets. Symbol-level synchronization in the opposite direction, i.e., from the outside-of-coverage of HR-MS toward the inside-of-coverage HR-MS shall be achieved by the outside-of-coverage HR-MS transmitting ranging signal toward the inside-of-coverage HR-MS. Upon processing the received ranging signal, the inside-of-coverage HR-MS can either adjust its own receive timing or request the outside-of-coverage HR-MS to adjust the transmit timing.

17.2.2.3.1 Use case 3: MS-MS direct communications; there is no HR-BS/RS

- The first level synchronization should be carried out in a Master-slave manner. It is understood that the master needs to take on some of the functionality of a BS and may also require new functionality.

- The second level of synchronization can be achieved by HR-MSs exchanging ranging signals.

An example of this scenario is when HR-MS1 and HR-MS2 are having direct communications in an infrastructure-less deployment (or due to single point of failure). For this, an HR-MS (which can be HR-MS1, HR-MS2, or another node) should first be elected as the network coordinator. It is assumed that either one or both HR-MS1 and HR-MS2 then are within the coverage of the elected coordinator. After being elected, the coordinator shall periodically broadcast preambles for frame-level synchronization. With this, the control is back to one of the two earlier scenarios.

17.2.2.4 HR-MS Direct Communication with Infrastructure Stations

HR-BS/HR-RS shall check DSA_REQ messages received from HR-MS and determine whether HR-MS direct communication can be adopted for a flow. The HR-BS/HR-RS may help the source and destination HR-MSs setting up a direct communication link through DSA signaling.

17.2.2.5 HR-MS Discovery for Direct Communication without Infrastructure

When HR-MS cannot receive any BS preamble from any infrastructure station or an HR-MS that is associated with an infrastructure station, and HR-MS direct communication without infrastructure is permitted by device configuration, then HR-MSs are allowed to transmit network discovery signals to the network.

The network discovery message shall take the following format: a frame preamble shall be transmitted first followed by discovery information.

When HR-MS sends out network discovery messages, to avoid collision with other HR-MSs, it should follow a random-back off mechanism as follows:
1) A back-off timer shall be started.
2) When the timer is timeout, HR-MS should sense the channel for the presence of preambles first. If no preambles detected, then the HR-MS should transmit the discovery message. If a preamble has been detected, then node should hold the transmission and restart the timer.
3) HR-MS should get the value for the duration of back-off from a window, for example, from a window of [w_{min}, w_{max}], the size of window can be adjusted based on the traffic of networks. The value of W_{min} and W_{max} are TBD.

17.2.3 HR-MS Forwarding to Network

17.2.3.1 General Description

In HR-MS Forwarding to Network, an HR-MS forwards user data and control signaling between an HR-MS and an HR infrastructure station. The user data and control signaling do not go through higher layer at the forwarding HR-MS. The origination and termination of the user data and control signaling are at the forwarded HR-MS and the HR infrastructure station respectively and vice versa.

HR-MS Forwarding to Network is applicable when 1) the forwarded HR-MS and the forwarding HR-MS are in coverage of and directly associated to an infrastructure station; 2) the forwarding HR-MS is in coverage of and directly associated to an HR infrastructure station, while the forwarded HR-MS is out of coverage of any HR infrastructure stations.

Resource for HR-MS Forwarding to Network can be allocated by the HR infrastructure station with which the forwarding HR-MS is associated.

17.2.3.2 Frame structure and resource allocation

See 17.2.2.2

17.2.3.3 Synchronization (this section is identical to 17.2.2.3)

See 17.2.2.3

17.2.3.4 Bandwidth Requests sent from Forwarded HR-MS

For use case 2, an out-of-coverage forwarded HR-MS can request bandwidth by transmitting some known sequences (Bandwidth Request (BR) preambles) toward the forwarding HR-MS.

The process can be described as follows.

- Serving HR-BS/RS schedules resources in an uplink subframe for forwarded HR-MSs to transmit BR messages to their corresponding forwarding HR-MS.
- The forwarding HR-MS listens to bandwidth requests at times and resources indicated by the HR-BS. The forwarded HR-MS may transmit bandwidth requests using these resources.
- The forwarding HR-MS, upon receiving BR messages from one of its forwarded HR-MS, forwards the requests to serving HR-BS/RS.
- Any resource assignment from the HR-BS is forwarded to the forwarding HR-MS.

17.2.4 Standalone network

For WirelessMAN HR-OFDMA air interface, when the HR-BS loses connectivity to the backbone network and the neighboring HR-BSs, the network stations under the coverage of this HR-BS shall form a standalone network. The local connectivity shall be provided for the HR-MS within the coverage of affected HR-BS. The established service flow between HR-MS within the coverage of the affected HR-BS shall be maintained.

17.2.4.1 Maintenance of Local Connectivity

For maintenance of local connectivity, all the HR-BSs shall maintain a network topology table of HR-MS/HR-RS within its coverage area. The network topology table shall be updated periodically by broadcasting STN-REQ message from HR-BS and receiving acknowledgement message STN-ACK from HR-MS or HR-RS within its coverage area.

17.2.4.2 Entry Process for Standalone Network

The HR standalone network with WirelessMAN HR-OFDMA air interface shall allow the entry of an unassociated HR-MS into the standalone network and establish the connection with standalone network HR-BS. The unassociated HR-MS is referred to the HR-MS which is not associated with any Base Station.

17.2.5 Relaying operation

Relay operation described in 802.16j-2009 shall be supported.

In order to provide great reliability in a degraded network, the relay function described in this subsection shall be supported.

In order to support local forwarding in an HR-Rs, the HR-Rs shall follow operation as defined in Section 17.2.6.

17.2.6 Local Forwarding

17.2.7 Path Discovery and Management

17.2.7.1 HR-MS Neighbor Discovery

HR-MS neighbor discovery is a key functionality to enable other 16n features such as path discovery and management, HR-MS direct communications (with or without presence of infrastructure), and HR-MS forwarding to network. HR-MS neighbor discovery procedures are specified for two scenarios: i) when HR-MSs associated with a common super-ordinate station (HR-BS/RS or a coordinating HR-MS) attempt to discovery each other and ii) when an out-of-coverage HR-MS attempts to discover an HR-MS in order to connect through it to network infrastructure.

17.2.7.1.1 Neighbor Discovery between Registered HR-MSs

For registered HR-MSs to discover each other, the serving HR-BS/HR-RS shall schedule some HR-MSs to broadcast predefined self-advertizing (PSA) signals so that other HR-MSs can try to receive and verify their neighbor relationship. Either ranging preambles or frame preambles (FFS) can be used as PSA signals.

The process of neighbor discovery for registered HR-MSs is as follows:

- The serving HR-BS/HR-RS schedules one or multiple registered HR-MSs to broadcast PSA sequences in assigned channels. Multiple HR-MSs may share the same PSA signal or the same channel PSA sequence or the same assigned channel, but not both.
- The serving HR-BS/HR-RS also schedules some other HR-MSs to listen on those channels scheduled for PSA signals.
- Each HR-MS that is scheduled to receive PSA sequences shall determine what sequences it can properly decode, together with related information such as estimations of time/frequency offsets and signal strength.
- The receiving HR-MSs may report their measurements to the serving HR-BS/HR-RS. Whether a receiving HR-MS shall report its measurements or not may be based on a threshold.

[Informative text] The serving HR-BS/HR-RS can determine neighbor topology based on reported measurements of transmitted PSA signals. The HR-MS is also able to construct a one hop neighborhood map that may be used for different purposes. How HR-BS/HR-RS/HR-MS construct neighbor topology is outside of the scope of this standard.

17.2.7.1.2 HR-MS Discover Network Infrastructure

For use case 2, The HR-BS may instruct HR-MS that are associated with it to transmit access information at pre-defined resources relative to the preambles transmitted by the HR-MS. The access information defines resources for access by the HR-MS that is not under HR-BS coverage. Access information may be omitted. If access information is omitted then access resources are defined by the index and the sub-carrier set index of the SA-Preamble. All or a group of the directly associated HR-MS may or may not transmit

the same access information on the same or different resources.

An unassociated HR-MS that detects the associated HR-MS preamble(s) shall subsequently receive access information to determine the access resource. If access information is omitted then access resources are determined from the SA-Preamble. The unassociated HR-MS transmits a CDMA preamble.

The associated HR-MS that received the CDMA preamble responds with sufficient access information to complete the association procedure.

17.2.7.2 Robustness against SPOF

17.2.7.2.1 Preparation for SPOF

In order to support Preparation for SPOF, alternative path described in this subsection shall be supported.
An alternative path may include HR-MS that switches mode to RS or BS.

Network entry including handover as described in 6.3.21 shall be supported in the event of SPOF. An indication of whether MAC context information of the subordinate HR-MS is being shared by infrastructure stations shall be transmitted to HR-MS.

To support fast network reentry to the neighbor HR-MSs, HR-MS shall transmit its neighbor information to HR-BS. HR-MSs capable of forwarding to the network and/or multimode operation shall share the MAC context information with the HR-MS performing local forwarding to the network.

If necessary, another path can be selected, if available, among alternative paths.

17.2.7.2.2 Recovery from SPOF

Network reentry including handover as described in 6.3.21 shall be supported in the event of SPOF. Whether MAC context information of the subordinate HR-MS is shared by the infrastructure stations shall be transmitted to HR-MS.

Alternative path may be selected during the role change or release the mode as described in 17.2.1.

17.2.8 Priority Access Operation

17.2.9 Multicast support

17.2.10 Security

17.2.10.1 Security Procedure for Direct Communication Data Security

17.2.10.1.1 Security Procedure for BS-coordinated Secure Direct Communication

In order to support BS-coordinated secure direct communication, the security procedure described in this subsection shall be executed between HR-MS, HR-BS, Authenticator, and AAA Server. HR-MSs received the security key from the HR-BS and use this security key for secure direct communication between/among HR-MSs.

17.2.10.1.1.1 Autonomous Mutual Authentication of HR-MS and data security for Direct Communications

17.2.10.1.1.1.1 Secure direct communication using pre-established shared key

In order to support secure direct communication between two or among more HR-MSs, pre-established shared key is used.

The pre-established shared key is established prior to the start of this direct communications.

17.2.10.1.1.1.2 Secure direct communication using Public Key Infrastructure

When pre-established shared key is not used for direct communication, Public Key Infrastructure shall be used.

Each HR-MS has a public/private key pair and digital certificate (e.g. X.509) issued by a certification authority for mutual authentication and key exchange prior to the start of this direct communications.

17.2.10.1.2 Security Procedure for Secure talk-around Direct Communication using dedicated resource

In order to support secure direct communication between two or among more HR-MSs, pre-established shared key is used.

17.2.10.2 Security Procedure for Multicast Operation

17.2.11 Self-Coexistence

HR network shall support self-coexistence mechanism to mitigate co-channel interference among HR-stations within the same geographical area.

17.2.11.1 Operation Modes

HR network can operate in two modes: normal mode and self-coexistence mode. A HR cell operates in normal mode by default and transits to self-coexistence mode when the

HR cell receives self-coexistence beacon from an adjacent HR cell on its operating channel.

17.2.11.2 Self-coexistence Zone

A self-coexistence zone is a space in a frame for transmission preamble and self-coexistence beacons for self-coexistence of multiple HR cells overlapped in coverage and have to operate on same frequency channel.

In WirelessMAN HR OFDMA networks, a self-coexistence zone occupies the last 3 symbols of a frame. The first symbol is used as guard time. In the second symbol, preamble shall be transmitted, and in the last symbol self-coexistence beacons are transmitted.

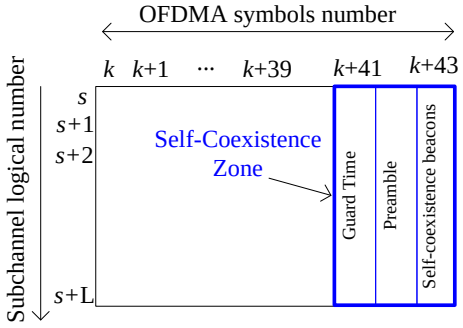

Figure xx Illustration of self-coexistence zone of WirelessMAN HR OFDMA air interface.

17.2.12 Support of Downlink High Reliability and Uplink Heavy Data Service

For HR-network operating in VHF band, it may use VHF mode of HR OFDMA air interface to support uplink heavy data service.

VHF mode of HR OFDMA air interface is OFDMA PHY-based with operating frequency in VHF band. The DL and UL tile structure specified in Figures 247a and 249a may be used in VHF mode. The modified DL tile structure is able to provide higher reliability of data link compared to DL PUSC cluster structure specified in 8.4.6.1.2.1. The modified tile structure for UL has lower pilot occupation rate which allows higher data rate compared to UL PUSC cluster structure specified in 8.4.6.2.1.

17.3 WirelessMAN HR Advanced air interface

17.3.1 Multi-mode operation

17.3.1.1 Relay function for HR-BS

An HR-BS (affected HR-BS) may operate as a relay station to communicate with another HR-BS (serving HR-BS) that has connection to backhaul.

An HR-BS acting as RS mode operates in either TTR mode or STR mode.

17.3.1.1.1 STR mode for HR-BS acting as HR-RS

To support STR mode, the affected HR-BS maintains base station functionality.

The procedures for RS mode change consist of following activities:

a) establish a relay link with a serving HR-BS

b) if necessary, inform some subordinate stations to perform handover

c) if necessary, reconfigure the physical frame and commence operation in relay mode

17.3.1.1.2 TTR mode for HR-BS acting as HR-RS

To support TTR mode, the affected HR-BS can maintain connectivity with subordinate HR-RS. How to maintain is FFS.

The procedures for RS mode change consist of following activities:

a) establish a relay link with a serving HR-BS

b) if necessary, inform some subordinate stations to perform handover

c) if necessary, reconfigure the physical frame and commence operation in relay mode

17.3.1.2 Relay function for HR-MS

An HR-MS may operate as an HR-RS to provide connectivity for multiple out-of-coverage HR-MSs. During basic capability negotiation within network entry, an HR-MS that is capable of role change to HR-RS shall report such capability to the super-ordinate HR-BS/HR-RS.

While operating as HR-RS, the station may maintain certain HR-MS functionalities. A mode switch to HR-RS shall be commanded by its superordinate HR-BS.

If the HR-MS release its role from the relay mode, HR-MS may perform handover to the any infrastructure station.

17.3.1.3 Base station function for HR-MS

An HR-MS may operate as an HR-BS to provide connectivity for itself and other HR-MSs. During basic capability negotiation within network entry, an HR-MS that is capable of role change to HR-BS shall report such capability to the super-ordinate HR-BS/HR-RS.

While operating as an HR-BS, the station may maintain certain HR-MS functionalities. A mode switch to HR-BS may be initiated by the HR-MS itself or may be directed by the superordinate HR-BS of the HR-MS.

17.3.2 Direct communication between HR-MSs

17.3.2.1 General Description

In HR-MS direct communication, the two communicating HR-MSs are the source and the sink of data. The data packets are passed from upper layers to MAC at the source HR-MS and back to upper layers at the sink HR-MS. Data packets are exchanged between the two HR-MSs directly or by passing through another HR-MS.

HR-MS direct communication is applicable when 1) the two HR-MSs are in coverage of and are directly associated to an HR infrastructure station; 2) one HR-MS is in coverage of and directly associated to an HR infrastructure station, while the other HR-MS is out of coverage of any HR infrastructure stations; 3) the two HR-MSs are out of coverage of any HR infrastructure stations.

Resource for HR-MS direct communication can be allocated by the HR infrastructure station for cases (1) and (2).

For case-3, direct communications between HR-MSs shall satisfies:

- The operation of HR-MSs shall not interfere with any existing infrastructure stations. When HR-MS cannot receive any BS preamble from any infrastructure station and HR-MS direct communication without infrastructure is permitted by device configuration, HR-MSs are allowed to communicate with each other in the same band without getting permission from infrastructure stations.
- A Coordinator is selected for the coordination of transmission among HR-MSs. Until a coordinator is selected, an HR-MS is only allowed to transmit signals necessary to enable coordinator selection. To avoid collisions among HR-MSs in coordinator selection, the HR-MS follow a collision avoidance procedure. The procedure is defined in 17.3.2.5.
- A coordinator shall function as a simplified HR-BS except it may not support handover. How to select a coordinator among HR-MSs shall follow the operation described in TBD.
- A coordinator supports the following topologies:
    5. HR-MS linked to the coordinator and the pair is the source and sink of data. This topology is implemented through the local source and sink capability of the HR-MS.
    6. Two HR-MS linked to the coordinator and the two HR-MS are the source and sink of data. This topology is implemented through the local

forwarding capability of the HR-BS.

7. A forwarding HR-MS forwards data of a forwarded HR-MS to the coordinator. This topology is implemented through the HR-BS capability to support HR-MS forwarding operation.

8. Two HR-MS are linked (DC) and are the source and sink of data to each other under the control of the coordinator. This topology is implemented through the HR-BS ability to support DC between its subordinates.

- The coordinator and any HR-MS that are communicating through the coordinator shall continue cell search operation and shall cease DC operation as soon as the criteria for DC and prevention of interference above are not met.

Resource for HR-MS direct communication may be allocated in a distributed manner among nearby HR-MSs independent of infrastructure node deployment for cases (1), (2), and (3).

HR-MS direct communication using distributed resource allocation among nearby HR-MSs, that is called talk-around direct communication, is described in 17.3.2.6.

17.3.2.2 Frame Structure and Resource Allocation

Resources for HR-MS Direct Communications and HR-MS Forwarding to Network shall be scheduled by the serving HR-BS/RS when one exists. Serving HR-BS/RS can schedule direct communication in an on-demand and dynamic manner, and can multiplex this with transmissions between HR-MS and HR-BS / HR-RS.

To optimize the signaling and switching cost and improve QoS provisioning to HR-MS direct communication, serving HR-BS / HR-RS can schedule resource for DC/FTN zone for multiplexing DC/FTN transmissions. An HR-MS DC / FTN Zone is an area of continuous OFDMA resources in time and logical subchannels or resource units. The size and location of DC/FTN zone is dynamically or semi-stationary determined by the serving HR-BS.

When an infrastructure node doesn’t exist, one of the HR-MS shall fulfill this coordinating role. It is understood that the coordinating HR-MS needs to take on some of the functionality of a HR-BS and may also require new functionality.

All resource scheduling shall be dynamically conveyed through MAP or DL control messages from serving HR-BS/RS or a coordinating HR-MS. In the case of HR-MS Forwarding to Network, the scheduling messages shall be forwarded by the forwarding HR-MS.

Random access channels may be used for bandwidth request. For case-1, bandwidth request are sent directly to the serving HR-BS /HR-RS. For case 2, bandwidth requests are forwarded by the forwarding HR-MS.

17.3.2.3 Synchronization

Synchronization between HR-MSs is classified into two levels:

- The frame-level (first level) should allow HR-MSs to share a common understanding of frame and/or superframe timing and configuration.
- The symbol-level (second level) should allow reliable (i.e. received within cyclic prefix) bi-directional transmissions between HR-MSs.

Synchronization mechanisms are specified for three different use cases as follows.

17.3.2.3.1 Use case 1: Both HR-MSs are within the coverage of HR-BS/RS

- The first level of synchronization shall be maintained by common DL signaling (i.e. preambles, FCH, MAP…) from HR-BS/RS.
- The second level of synchronization can be achieved by HR-MSs exchanging ranging signals.

The following synchronization mechanisms are specifically designed for the case when HR-MS DC and FTN are scheduled in UL area of a frame.

Frame-level Synchronization:

When both HR-MSs are able to receive preambles and DL control signals from HR-BS/HR-RS, they shall use these to achieve frame-level synchronization (with respect to HR-BS/HR-RS and between themselves). When both HR-MSs involved in DC or FTN are within the coverage of HR-BS/HR-RS, frame-level synchronization means the HR-MSs acquire DL synchronization with the serving HR-BS/HR-RS and are able to achieve system configuration and control messages.

Symbol-level Synchronization:

When the HR-MS/HR-MS direct link is scheduled in a UL area of a frame, the transmitting HR-MS shall follow the same timing advance as has been adjusted and agreed with the serving HR-BS/HR-RS. This means the transmitting HR-MS shall time its direct transmissions as if these are normal UL transmissions toward the serving HR-BS/HR-RS.

It is the responsibility of the receiving HR-MS to adjust its receive timing to match the time of arrival (TOA) of the signal transmitted by the other HR-MS. This time adjustment shall be achieved by the serving HR-BS/HR-RS scheduling the HR-MSs to transmit ranging sequences to each other. Based on a received ranging sequence, an HR-MS can estimate and correct its time offset with the transmitting HR-MS. To facilitate this process, the serving HR-BS/HR-RS shall assign dedicated ranging sequences and ranging channels in UL area of a frame for HR-MS/HR-MS direct ranging.

To enhance bi-directional communication between HR-MSs, the serving HR-BS/HR-RS can allocate ranging resources to both involved HR-MSs in a single assignment. This allows the receiving HR-MS to transmit back a ranging sequence right after successfully processing the ranging sequence transmitted by the other HR-MS.

17.3.2.3.2 Use case 2: one HR-MS is inside and the other is outside the coverage of HR-BS/RS

- The first level of synchronization shall be achieved by the inside-of-coverage HR-MS transmitting preamble and in some cases network configuration information toward the outside-of-coverage HR-MS. The locations of these control signals are TBD. HR-MS that are associated with an HR-BS transmit preambles at known locations. For AAI baseline the PA-Preamble alone or PA-Preamble and SA-Preamble may be used. The preamble location and conditions for transmission are TBD.

- The second level of synchronization can be achieved by HR-MSs exchanging ranging signals.

The following synchronization mechanisms are specifically designed for the case when HR-MS DCm and FTN are scheduled in UL area of a frame.

Frame-level Synchronization:

When two HR-MSs need to achieve frame-level synchronization and only one of them is within the coverage of and registered with an HR-BS/HR-RS, the registered HR-MS shall first acquires DL synchronization with the serving HR-BS/HR-RS (based on preambles and control messages from the serving HR-BS/HR-RS). The registered HR-MS shall subsequently broadcast preambles and possibly network configuration information (NCI) for the outside-of-coverage HR-MS to co-synchronize.

For 16m baseline, the registered HR-MS shall transmit PA/SA preambles at the first OFDMA symbols of 2^{nd} and 3^{rd} frames within each superframe. The NCI shall be transmitted in an UL area. The location of the NCI, relative to the transmitted preambles, shall be determinable by the outside-of-coverage HR-MS.

Symbol-level Synchronization:

Using the preambles and NCI transmitted by the inside-of-coverage HR-MS, the outside-of-coverage HR-MS shall adjust its timing to receive messages transmitted from the inside-of-coverage HR-MS. To further improve synchronization in this direction, the inside-of-coverage HR-MS can transmit ranging signal toward the outside-of-coverage HR-MS so that this node can estimate and correct its time/frequency offsets. Symbol-level synchronization in the opposite direction, i.e., from the outside-of-coverage of HR-MS toward the inside-of-coverage HR-MS shall be achieved by the outside-of-coverage HR-MS transmitting ranging signal toward the inside-of-coverage HR-MS. Upon processing the received ranging signal, the inside-of-coverage HR-MS can either adjust its own receive timing or request the outside-of-coverage HR-MS to adjust the transmit timing.

17.3.2.3.3 Use case 3: MS-MS direct communications; there is no HR-BS/RS

- The first level synchronization should be carried out in a Master-slave manner. It is understood that the master needs to take on some of the functionality of a BS and may also require new functionality.

- The second level of synchronization can be achieved by HR-MSs exchanging ranging signals.

An example of this scenario is when HR-MS1 and HR-MS2 are having direct communications in a infrastructure-less deployment (or due to single point of failure). For this, an HR-MS (which can be HR-MS1, HR-MS2, or another node) should first be elected as the network coordinator. It is assumed that either one or both HR-MS1 and HR-MS2 then are within the coverage of the elected coordinator. After being elected, the coordinator shall periodically broadcast preambles for frame-level synchronization. With this, the control is back to one of the two earlier scenarios.

17.3.2.4 HR-MS Direct Communication with Infrastructure Stations

HR-BS/HR-RS shall check DSA_REQ messages received from HR-MS and determine whether HR-MS direct communication can be adopted for a flow. The HR-BS/HR-RS may help the source and destination HR-MSs setting up a direct communication link through DSA signaling.

17.3.2.5 HR-MS Discovery for Direct Communication without Infrastructure

When HR-MS cannot receive any BS preamble from any infrastructure station or an HR-MS that is associated with an infrastructure station, and HR-MS direct communication without infrastructure is permitted by device configuration, then HR-MSs are allowed to transmit network discovery signals to the network.

The network discovery message shall take following format: frame preambles, PA-Preamble and SA-Preamble shall be transmitted first followed by the discovery information.

When HR-MS sends out network discovery messages, to avoid collision with other HR-MSs, it should follow a random-back off mechanism as follows:
1) A back-off timer shall be started.
2) When the timer is timeout, HR-MS should sense the channel for the presence of preambles first. If no preambles detected, then the HR-MS should transmit the discovery message. If a preamble has been detected, then node should hold the transmission and restart the timer.
3) HR-MS should get the value for the duration of back-off from a window, for example, from a window of [w_{min}, w_{max}], the size of window can be adjusted based on the traffic of networks. The value of W_{min} and W_{max} are TBD.

17.3.2.6 Talk-around Direct Communication

HR-MSs by themselves synchronize and perform contention-based transmission. The synchronization and the contention-based transmission are performed among those HR-MSs on a dedicated resource unused by HR-BSs if at least one of the HR-MSs are under HR-BS coverage.

17.3.2.6.1 Medium access control

17.3.2.6.1.1 MAC control messages

17.3.2.6.2 Physical layer

17.3.2.6.2.1 Frame structure

17.3.2.6.2.2 Physical structure

17.3.2.6.2.3 Control structure

17.3.3 HR-MS Forwarding to Network

17.3.3.1 General Description

In HR-MS Forwarding to Network, an HR-MS forwards user data and control signaling between an HR-MS and an HR infrastructure station. The user data and control signaling do not go through higher layer at the forwarding HR-MS. The origination and termination of the user data and control signaling are at the forwarded HR-MS and the HR infrastructure station respectively and vice versa.

HR-MS Forwarding to Network is applicable when 1) the forwarded HR-MS and the forwarding HR-MS are in coverage of and directly associated to an infrastructure station; 2) the forwarding HR-MS is in coverage of and directly associated to an HR infrastructure station, while the forwarded HR-MS is out of coverage of any HR infrastructure stations.

Resource for HR-MS Forwarding to Network can be allocated by the HR infrastructure station with which the forwarding HR-MS is associated.

Using talk-around direct communication described in 17.3.2.6, HR-MS forwarding to network is described in 17.3.3.5.

17.3.3.2 Frame structure and Resource Allocation

See 17.3.2.2

17.3.3.3 Synchronization

See 17.3.2.3

17.3.3.4 Bandwidth Requests sent from Forwarded HR-MS

For use case 2, an out-of-coverage forwarded HR-MS can request bandwidth by transmitting some known sequences (Bandwidth Request (BR) preambles) toward the forwarding HR-MS.

The process can be described as follows.

- Serving HR-BS/RS schedules resources in an uplink subframe for forwarded HR-MSs to transmit BR messages to their corresponding forwarding HR-MS.
- The forwarding HR-MS listens to bandwidth requests at times and resources indicated by the HR-BS. The forwarded HR-MS may transmit bandwidth requests using these resources.
- The forwarding HR-MS, upon receiving BR messages from one of its forwarded HR-MS, forwards the requests to serving HR-BS/RS.
- Any resource assignment from the HR-BS is forwarded to the forwarding HR-MS.

17.3.3.5 HR-MS forwarding to network using talk-around direct communication

17.3.3.5.1 HR-MS discoveries

17.3.3.5.2 Connection management

17.3.3.5.3 Forwarding Link management

17.3.3.5.4 QoS management

17.3.3.5.5 Paging

17.3.4 Standalone network

For WirelessMAN HR Advanced air interface, when HR-BS lost the connectivity to the backbone network and the neighboring HR-BSs, the network nodes under the coverage of this HR-BS shall form a standalone network. The local connectivity shall be provided for the mobile stations within the coverage of Base station. When the Base Station loses the backbone connection, the established service flow between mobile stations within the coverage of the base station shall be maintained.

When backbone connectivity is lost, the MAC connectivity is provided among HR-MSs within BS's coverage

17.3.4.1 Backbone status management

17.3.4.1.1 Backbone Enable notification

When backbone connectivity is available, the HR-BS shall notify HR-MSs of its availability. The transport connections may be recovered from their unavailable status.

An HR-BS exchanges the BBE-REQ/RSP message with HR-MSs on unicast control connections.

An HR-BS broadcasts the BBE-CMD message to all the HR-MSs under BS's coverage.

17.3.4.1.2 Backbone Disable notification

When backbone connectivity is not available, the HR-BS shall notify HR-MSs of its unavailability. After backbone disables, all the transport connections on which packets transfer to network are not available.

An HR-BS exchanges the BBD-REQ/RSP message with HR-MSs on unicast control connections.

An HR-BS broadcasts the BBD-CMD message to all the HR-MSs under BS coverage.

17.3.4.2 Maintenance of Local Connectivity

For maintenance of local connectivity, all the HR-BSs shall maintain a network topology table of HR-MS/HR-RS within its coverage area. The network topology table shall be updated periodically by broadcasting a STN-REQ message from HR-BS and receiving acknowledgement message STN-ACK from HR-MS or HR-RS within its coverage area.

The maintenance of local connectivity for standalone network with WirelessMAN HR Advanced air interface shall according to the process defined in section 17.2.4.1

17.3.4.3 Entry Process for Standalone Network

The HR standalone network with WirelessMAN HR Advanced air interface shall allow the entry of an unassociated HR-MS into the standalone network and establish the connection with standalone network HR-BS. The unassociated HR-MS is referred to the HR-MS which is not associated with any Base Station.

The entry process is as defined in Section 17.2.4.2.

17.3.5 Relaying operation

Relay operation described in Section 16.6 shall be supported.

In order to provide great reliability in a degraded network, the relay function described in this subsection shall be supported.

In order to support local forwarding in an HR-RS, the HR-RS shall follow operation as defined in Section 17.3.6.

17.3.6 Local Forwarding

HR-RS/BS should detect the local forwarding opportunity and be able to bind together the uplink flow ID from the source and the downlink flow ID to the destination for two communicating HR-MSs within its control during connection establishment or connection re-establishment for handover, if it is allowed by HR-BS. After the binding HR-RS is able to forward the data from the source to the destination without going through HR-BS and may optionally forward to HR-BS one copy of the data that is being locally forwarded, if required.

17.3.7 Path Discovery and Management

17.3.7.1 HR-MS Neighbor Discovery

HR-MS neighbor discovery is a key functionality to enable other 16n features such as path discovery and management, HR-MS direct communications (with or without presence of infrastructure), and HR-MS forwarding to network. HR-MS neighbor discovery procedures are specified for two scenarios: i) when HR-MSs associated with a common super-ordinate station (HR-BS/RS or a coordinating HR-MS) attempt to discovery each other and ii) when an out-of-coverage HR-MS attempts to discover an HR-MS in order to connect through it to network infrastructure.

To enable neighbor discovery among directly associated HR-MSs (use case 1), the super-

ordinate station shall instruct these directly associated HR-MSs to transmit and receive predefined signals.

17.3.7.1.1 Neighbor Discovery between Registered HR-MSs

For registered HR-MSs to discover each other, the serving HR-BS/HR-RS shall schedule some HR-MSs to broadcast predefined self-advertizing (PSA) signals so that other HR-MSs can try to receive and verify their neighbor relationship. Either ranging preambles or frame preambles (FFS) can be used as PSA signals.

The process of neighbor discovery for registered HR-MSs is as follows:

- The serving HR-BS/HR-RS schedules one or multiple registered HR-MSs to broadcast PSA sequences in assigned channels. Multiple HR-MSs may share the same PSA signal or the same channel PSA sequence or the same assigned channel, but not both.
- The serving HR-BS/HR-RS also schedules some other HR-MSs to listen on those channels scheduled for PSA signals.
- Each HR-MS that is scheduled to receive PSA sequences shall determine what sequences it can properly decode, together with related information such as estimations of time/frequency offsets and signal strength.
- The receiving HR-MSs may report their measurements to the serving HR-BS/HR-RS. Whether a receiving HR-MS shall report its measurements or not may be based on a threshold.

[Informative text] The serving HR-BS/HR-RS can determine neighbor topology based on reported measurements of transmitted PSA signals. The HR-MS is also able to construct a one hop neighborhood map that may be used for different purposes. How HR-BS/HR-RS/HR-MS construct neighbor topology is outside of the scope of this standard.

17.3.7.1.2 HR-MS Discover Network Infrastructure

To enable coverage extension, a serving HR-BS/HR-RS shall schedule some of its registered HR-MSs to transmit PA/SA preamble signals so that an outside-of-coverage HR-MS can detect and start network entry. The registered HR-MS shall transmit PA preamble at the beginning of the 2^{nd} frame and SA preamble at the beginning of the 3^{rd} frame (of a super-frame).

Any non-registered HR-MS scanning for DL preambles for possible network entry shall be able to differentiate between preambles transmitted by normal infrastructure stations (HR-BS/HR-RS) and those transmitted by a coverage-extending HR-MS.

For use case 2, The HR-BS may instruct HR-MS that are associated with it to transmit access information at pre-defined resources relative to the preambles transmitted by the HR-MS. The access information defines resources for access by the HR-MS that is not

under HR-BS coverage. Access information may be omitted. If access information is omitted then access resources are defined by the index and the sub-carrier set index of the SA-Preamble. All or a group of the directly associated HR-MS may or may not transmit the same access information on the same or different resources.

An unassociated HR-MS that detects the associated HR-MS preamble(s) shall subsequently receive access information to determine the access resource. If access information is omitted then access resources are determined from the SA-Preamble. The unassociated HR-MS transmits a CDMA preamble.

The associated HR-MS that received the CDMA preamble responds with sufficient access information to complete the association procedure.

17.3.7.2 Robustness against SPOF

17.3.7.2.1 Preparation for SPOF

In order to support preparation for SPOF, alternative path described in this subsection shall be supported.
An alternative path may include HR-MS that switches mode to RS or BS.

Network entry including handover as described in 16.2.6 and 16.2.8.2.9 shall be supported in the event of SPOF. An indication of whether MAC context information of the subordinate HR-MS is being shared by infrastructure stations shall be transmitted to HR-MS.

To support fast network reentry to the neighbor HR-MSs, HR-MS shall transmit its neighbor information to HR-BS. HR-MSs capable of forwarding to the network and/or multimode operation shall share the MAC context information with the HR-MS performing local forwarding to the network.

If necessary, another path can be selected, if available, among alternative paths.

17.3.7.2.2 Recovery from SPOF

Network reentry including handover as described in 16.2.6 and 16.2.8.2.9 shall be supported in the event of SPOF. Whether MAC context information of the subordinate HR-MS is shared by the infrastructure stations shall be transmitted to HR-MS.

Alternative path may be selected during the role change or release the mode as described in 17.3.1.

17.3.8 Priority Access Operation

17.3.9 Multicast support

Each HR-BS capable of providing multicast communication belongs to a certain multicast group zone. A multicast zone defined as a set of HR-BSs where the same Multicast Group ID and FID is used for transmitting the content of certain service flow(s).

An HR-BS may provide the HR-MS with multicast content locally within its coverage and independently of other HR-BSs. The single HR-BS provision of multicast is therefore a configuration where a Multicast Zone is configured to consist of a single HR-BS only. In this case, the HR-BS uses any Multicast Group ID and FID for providing multicast service, independently of other HR-BSs, so the HR-MS received the multicast data from its serving HR-BS, and the HR-MS should not expect the service flow for this multicast connection to continue when the HR-MS leaves the serving HR-BS' coverage. However, if the HR-MS moves to an HR-BS that is transmitting the same multicast flow in another HR Multicast Group Zone, HR-MS may update its service flow management encodings to continue to receive the same multicast flows.

To ensure proper multicast operation on networks of HR-BS employing multicast, the Multicast Group IDs and FIDs used for common multicast content and service shall be the same for all HR-BSs within the same HR Multicast Group Zone. This allows the HR-MS which has already registered with a service to be seamlessly synchronized with multicast transmissions within an HR Multicast Group Zone without communicating in the UL or re-registering with other HR-BS within that HR Multicast Group Zone.

17.3.9.1 Multicast communication operation

An HR-BS establishes a DL multicast service by creating a multicast connection with each HR-MS to be associated with the service. Multicast service flows are not dedicated to the specific HR-MS and are maintained even though the HR-MS is either connected state or idle state. When an HR-MS is registered at an HR-BS for receiving multicast service, multicast service flows shall be instantiated as multicast connections. An HR-MS regardless of what mode the HR-MS is currently in may receive data of multicast service flows transmitted from HR-BS. Any available FID is used for the multicast service (i.e., there are no dedicated FIDs for multicast transport connections). To ensure proper multicast operation, the Multicast Group ID and FID used for the service shall be the same for all HR-MSs on the same channel that participate in the connection in a multicast zone. Mapping of multicast service flows to corresponding Multicast Group IDs and FIDs shall be known and be the same for all HR-BSs belonging to the same HR Multicast Group Zone.

17.3.9.1.1 Multicast communication establishment

The procedure of multicast communication establishment includes capacity exchange, establishment multicast connection, transmission and receiving the HR-multicast control channel as shown in Figure xxx. The procedure includes

- Capacity exchange using AAI-REG-REQ/RSP
- DSx procedure containing relevant multicast parameter to establish multicast

connection

- Transmission and receiving the HR multicast control channel

To discover multicast service, HR-MS will inform HR-BS of support of multicast transmission by AAI-REG-REQ message and the HR-BS will indicate if it supports multicast for that HR-MS through AAI-REG-RSA message. The basic multicast capability exchange in AAI_REG-REQ/RSP message is described in 16.2.3.8 and 16.2.3.9.

When an HR-MS registers to receive multicast services, the serving HR-BS or the HR-MS may initiate the DSA procedure for multicast connections. The HR-MS's discovery and registration of multicast services with the HR-BS through upper layer signaling are outside the scope of this standard.

The AAI-DSA, AAI-DSC and AAI-DSD messages are used to establish, change, and delete multicast service flows respectively. The HR-BS shall send the AAI-DSA-REQ/RSP to the HR-MS with the relevant multicast parameters including Multicast Group ID.

To receive multicast data, an HR-MS receives the multicast allocation information in the multicast control channel (i.e., multicast assignment MAP).

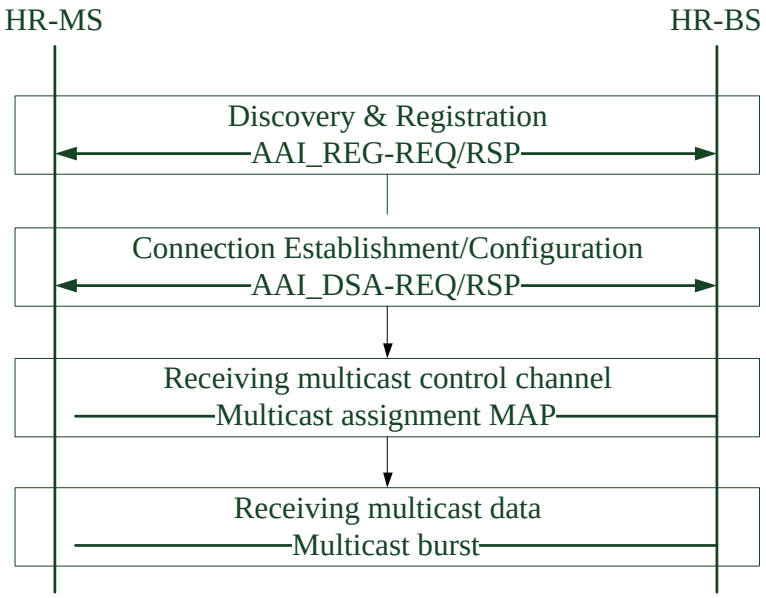

Figure xxx – Procedure of multicast communication establishment

17.3.9.1.2 Multicast communication operation in connected state

When an HR-MS moves across Multicast zone boundaries in Active Mode or Sleep Mode, the HR-MS performs the handover procedure as described in 16.2.6.3.

When the HR-MS transits to a new Multicast Zone while in Active Mode or Sleep Mode, the HR-MS shall send AAI-RNG-REQ message with Ranging Purpose Indication = 0b1110 at the target HR-BS and the ABS shall include Multicast Group ID and FID Update in AAI-RNG-RSP parameters to provide updated service flow management encodings for any affected E-MBS flow as part of the handover procedure.

17.3.9.1.3 Multicast communication operation in idle state

When an HR-MS in Idle state moves to an HR-BS which does not belong to HR-MS' previous Multicast Group Zone, the HR-MS is expected to update the multicast service flow management encodings at that HR-BS to provide continuous reception of multicast content. The HR-MS may obtain the multicast information in the target Multicast zone through broadcast messages in the Multicast Zone of the service HR-BS. If the idle HR-MS has not received such information from the serving Multicast Zone, the HR-MS shall use location update procedure to acquire updated multicast service flow management encodings. In order to perform the multicast location update process, the HR-MS shall transmit AAI-RNG-REQ message with Ranging Purpose Indication = 0b1110. In response to the request for multicast location update, the HR-BS shall transmit AAI-RNG-RSP message which may include the Multicast Group Zone identifier, Multicast Group ID, and FID to provide update service flow management encodings for any affected multicast flow(s).

17.3.9.2 Multicast protocol features and functions

17.3.9.2.1 Downlink control channel for multicast communication

HR-multicast control channel (i.e., HR-Multicast DL Assignment A-MAP IE) carries configuration information (including allocation/change/releasement) for multicast communication for one multicast zone in an HR-BS. In HR-Multicast DL Assignment A-MAP, allocation period indicates a period of persistent allocation of multicast resource and Lifetime is a timer indicating the next instance of HR-Multicast DL-Assignment A-MAP IE. Unless the Lifetime expires, this HR-Multicast DL Assignment A-MAP does not change during the allocation duration. At the time the Lifetime expires, the HR-Multicast DL Assignment A-MAP shall change or release the allocation.

Table xx – HR-Multicast DL Assignment A-MAP IE*

Syntax	Size (bit)	Description/Notes
HR-Multicast_DL_Assignment_A-MAP_IE() {		
A-MAP IE Type	4	HR-Multicast DL Assignment A-MAP

		IE
Allocation period	2	Period of persistent allocation of multicast resource. If (Allocation Period==0b00), it indicates the deallocation of persistent resource. 0b00: deallocation 0b01: 2 frames 0b10: 4 frames 0b11: 6 frames
If (Allocation Period == 0b00) {		
Resource Index	11	5 MHz: 0 in first 2 MSB bits + 9 bits for resource index 10 MHz: 11 bits for resource index 20 MHz: 11 bits for resource index Resource index includes location and allocation size.
Long TTI Indicator	1	Indicates number for AAI subframes spanned by the allocated resource. 0b0: 1 AAI subframe (default TTI) 0b1: 4 DL AAI subframe for FDD or all DL AAI subframes for TDD (long TTI)
Reserved	22	
} else if(Allocation Period != 0b00) {		
Isizeoffset	5	Offset used to compute burst size index
MEF	2	MIMO encoder format 0b00: SFBC 0b01: Vertical encoding 0b10: Multi-layer encoding 0b11: CDR
If (MEF ==0b01) {		Parameter for vertical encoding
M_t	3	Number of streams in transmission $M_t <= N_t$ N_t: Number of transmit antennas at the HR-BS 0b000: 1 stream 0b001: 2streams 0b010: 3streams 0b011: 4streams 0b100: 5streams 0b101: 6streams

		0b110: 7streams 0b111: 8streams
Reserved	1	
} else if (MEF == 0b10) {		Parameters for multi-layer encoding
Si	4	Index to identify the combination of the number of streams and the allocated pilot stream index in a transmission with MU-MIMO, and the modulation constellation of paired user in the case of 2 stream transmission 0b0000: 2 streams with PSI=stream1 and other modulation = QPSK 0b0001: 2 streams with PSI=stream1 and other modulation = 16QAM 0b0010: 2 streams with PSI=stream1 and other modulation = 64QAM 0b0011: 2 streams with PSI=stream1 and other modulation information not available 0b0100: 2 streams with PSI=stream2 and other modulation =QPSK 0b0101: 2 streams with PSI=stream2 and other modulation =16QAM 0b0110: 2 streams with PSI=stream2 and other modulation =64QAM 0b0111: 2 streams with PSI=stream2 and other modulation information not available 0b1000: 3 streams with PSI=stream1 0b1001: 3 streams with PSI=stream2 0b1010: 3 streams with PSI=stream3 0b1011: 4 streams with PSI=stream1 0b1100: 4 streams with PSI=stream2 0b1101: 4 streams with PSI=stream3 0b1110: 4 streams with PSI=stream4 0b1111: n/a
}		
Resource Index	11	5 MHz: 0 in first 2 MSB bits + 9 bits for resource index 10 MHz: 11 bits for resource index 20 MHz: 11 bits for resource index Resource index includes location and allocation size.
Long TTI Indicator	1	Indicates number for AAI subframes spanned by the allocated resource.

		0b0: 1 AAI subframe (default TTI) 0b1: 4 DL AAI subframe for FDD or all DL AAI subframes for TDD (long TTI)
Lifetime(L)	4	Indicates the time to transmit next HR-Multicast DL Assignment A-MAP and the information of this HR-Multicast DL Assignment A-MAP does not change during the allocation duration. The next HR-Multicast DL Assignment A-MAP is at the superframe whose superframe number, Nsuperframe, satisfies the following condition. Nsuperframe modulo L+1 = 0
Reserved	7	
}		
}		

*A 16bit CRC is generated based on the randomized contents of the HR-Multicast DL Assignment A-MAP IE. The CRC is masked by the 16-bit CRC mask (with masking prefix = 0b0 and message type indicator = 0b010) generated according to Table 843 as describe in 16.3.5.5.2.4.

17.3.9.3 Multicast key management

Multicast key is managed as described in 17.3.10.2.

17.3.10 Security

17.3.10.1 Security Procedure for Direct Communication Data Security

17.3.10.2 Security Procedure for Multicast Operation

17.3.11 Self-Coexistence

HR network shall support self-coexistence mechanism to mitigate co-channel interference among HR-stations within the same geographical area.

17.3.11.1 Operation Modes

See 17.2.11.1.

17.3.11.2 Self-coexistence Zone

A self-coexistence zone is a space in a frame for transmission preamble and self-coexistence beacons for self-coexistence of multiple HR networks overlapped in coverage and have to operate one same frequency channel.

The structure of self-coexistence zone in WirelessMAN HR Advanced networks is TBD.