IEEE P802.22b™/D1.0
Draft Standard for Wireless Regional Area Networks Part 22: Cognitive Wireless RAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Policies and procedures for operation in the TV Bands - Amendment: Enhancement for broadband services and monitoring applications

Prepared by the IEEE 802.22 Working Group of the

LAN/MAN Standards Committee
of the
IEEE Society

Abstract: This standard specifies alternate Physical Layer (PHY) and necessary Medium Access Control Layer (MAC) enhancements to IEEE std. 802.22-2011 for operation in Very High Frequency (VHF)/ Ultra High Frequency (UHF) TV broadcast bands between 54 MHz and 862 MHz to support enhanced broadband services and monitoring applications. The standard supports aggregate data rates greater than the maximum data rate supported by the IEEE Std. 802.22-2011. This standard defines new classes of 802.22 devices to address these applications and supports more than 512 devices in a network. This standard also specifies techniques to enhance communications among the devices and makes necessary amendments to the cognitive, security & parameters and connection management clauses. This amendment supports mechanisms to enable coexistence with other 802 systems in the same band.

Keywords: broadband wireless access network, enhanced broadband services, monitoring applications, high throughput, high capacity, WRAN standards

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An introduction shall be supplied by the working group, giving the history of the standard, a description of its purpose, and, if the standard is a revision, an explanation of the principal changes from the previous edition. The introduction should also explain the document structure for multipart standards, or for documents within a family of standards (see 10.5 of the 2012 IEEE Style Manual for more details).

Contents

IEEE Draft Standard for Wireless Regional Area Networks Part 22: Cognitive Wireless RAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Policies and procedures for operation in the TV Bands - Amendment: Enhancement for broadband services and monitoring applications

1. Overview

1.1 Scope

This amendment specifies alternate Physical Layer (PHY) and necessary Medium Access Control Layer (MAC) enhancements to IEEE std. 802.22-2011 for operation in Very High Frequency (VHF) / Ultra High

Frequency (UHF) TV broadcast bands between 54 MHz and 862 MHz to support enhanced broadband services and monitoring applications. The standard supports aggregate data rates greater than the maximum data rate supported by the IEEE Std. 802.22-2011. This standard defines new classes of 802.22 devices to address these applications and supports more than 512 devices in a network. This standard also specifies techniques to enhance communications among the devices and makes necessary amendments to the cognitive, security & parameters and connection management clauses. This amendment supports mechanisms to enable coexistence with other 802 systems in the same band.

1.2 Purpose

The purpose of this amendment is to enhance the MAC and define an alternate PHY to accommodate broadband extensions and monitoring use cases for IEEE 802.22 devices operating is VHF/UHF TV broadcast bands between 54 MHz and 862 MHz.

2. Normative references

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

3. Definitions

As of June 2009, please use the following introductory paragraph and there is no requirement to number definitions. Please refer to the 2009 Style Manual for updates (http://standards.ieee.org/guides/style/2009_Style_Manual.pdf). To format terms and definitions in the IEEE-SA word template, you may NOW simply bold the “term:” and use regular text for the definitions. **DO NOT USE the IEEEStds Definitions or IEEEStds DefTerms+Numbers** style. However, if the definitions have already been numbered with the template tool, STAFF will remove the numbering during the publication process. (NOTE: There are instances when a draft will need to number terms - please consult with an IEEE-SA editor).

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4. Abbreviations and acronyms

MRBS

5. System architecture

6. Packet convergence sublayer

7. MAC Common Part sublayer

Change the paragraph as follows:

This clause describes the MAC layer used by the IEEE 802.22 WRAN point-to-multipoint medium access control standard and the IEEE 802.22b multihop relay WRAN (MR-WRAN) multihop relay medium access control standard. The MAC provides tools for protection of TV bands incumbent services as well as for coexistence. The MR-WRAN MAC provides all functionalities of the WRAN MAC, and additionally supports multihop relay operations, multiple channel operations, multiple input multiple output (MIMO) operations, etc. The MAC isThe both WRAN and MR-WRAN MACs are connection-oriented and provides flexibility in terms of QoS support. The MAC regulatesThe WRAN MAC and the MR-WRAN MAC regulate downstream medium access by TDM, while the upstream is managed by using a DAMA/OFDMA system. In the WRAN MAC, the BS manages all the activities within its IEEE 802.22 cell and the associated CPEs are under the control of the BS. The MR-WRAN MAC provides point-to-multipoint connections and relay connections between the multihop relay base station (MR-BS) and the CPEs within an MR-BS's cell as well as supports to configure a local cell consisting of a distributed scheduling relay CPE (R-CPE) and subscriber CPEs (S-CPEs). A relay CPE (R-CPE) shall operate one of two modes of centralized scheduling mode and distributed scheduling mode depending on capability or network situations. The R-CPE on the centralized scheduling mode (called a centralized scheduling R-CPE) provides relay connections for the subscriber CPEs (S-CPEs) under the management of the MR-BS. On the other hand, the R-CPE on the distributed scheduling mode (called a distributed scheduling R-CPE) may configure a local cell, and has the similar functionalities of MR-BS and manages S-CPEs within the local cell. The MR-BS manages the MR-WRAN cell containing CPEs and local cells.

7.1 General

Insert the following paragraph as the second paragraph of section 7.1:

In an MR-WRAN cell consisting of CPEs (e.g., R-CPEs and S-CPEs), all R-CPEs and multiple S-CPEs are managed by a single MR-BS, and other S-CPEs are managed by distributed scheduling R-CPEs. The downstream is TDM where the MR-BS transmits and the CPEs receive. The upstream transmissions, where the CPEs transmit and the MR-BS receives, are shared by the CPEs on a demand basis, according to a DAMA/OFDMA scheme. Within a local cell consisting of a distributed scheduling R-CPE and S-CPEs, multiple S-CPEs are managed by the distributed scheduling R-CPE. The downstream within a local cell is TDM where the distributed scheduling R-CPE transmits and the S-CPEs receive. The upstream transmissions within a local cell, where the S-CPEs transmit and the distributed scheduling R-CPE receives, are shared by the S-CPEs on a demand basis, according to a DAMA/OFDMA scheme.

Change the second and third paragraphs as follows:

The both WRAN MAC and MR-WRAN MAC implements a combination of access schemes that efficiently control contention between CPEs within a cell and overlapping cells sharing the same channel while at the same time attempting to meet the latency and bandwidth requirements of each user application. This is accomplished through four different types of upstream scheduling mechanisms that are implemented using: unsolicited bandwidth grants, polling, and two contention procedures (i.e., MAC header and CDMA based). The use of polling simplifies the access operation and attempts to allow applications to receive service on a deterministic basis if it is required.

The both WRAN MAC and MR-WRAN MAC isare connection-oriented, and as such, connections are a key component that require active maintenance and hence can be dynamically created, deleted, and changed as the need arises. A connection defines both the mapping between convergence processes at CPEs and BS or MR-BS and the related service flow (one connection per service flow). For the purposes of mapping to services on CPEs and associating varying levels of QoS, all data communications are instantiated in the context of a connection and this provides a mechanism for upstream and downstream QoS management. In particular, the QoS parameters are integral to the bandwidth allocation process as the CPE requests upstream bandwidth on a per connection basis (implicitly identifying the service flow). The BS, MR-BS or the distributed scheduling R-CPE, in turn, grants bandwidth to a CPE as an aggregate of grants in response to per-connection requests from the CPE.

7.2 Addressing and connections

Insert the following paragraph after the first paragraph in section 7.2:

Each MR-BS and CPE shall have a 48-bit universal MAC address, as defined in IEEE Std 802-2001. This address uniquely defines the MR-BS and CPE from within the set of all possible vendors and equipment types. It is used as part of the authentication process by which the MR-BS and CPE each verify the identity of the other at the time of network association.The MR-BS MAC address is broadcast by the MR-BS on superframe control header (SCH) on PHY Mode 1 (Clause 9-) or frame control header (FCH) on PHY Mode 2 (Clause 9a) and is present in every CBP burst. Each MR-WRAN device regularly broadcasts a CBP burst containing its Device ID and Serial Number. This is done as part of the device's self-identification process that helps identify potential interference sources to incumbent services and for coexistence purposes.

Change the second paragraph as follows:

(Note 1: Increasing SID to support a larger number of CPEs in an MR-WRAN)

(Note 2: Local cell ID defines a local cell identification for an MR-WRAN)

(Note 3: Separation of downstream FID and upstream FID to support different services for downstream and upstream)

Connections are identified by ~~two~~three items, a 8-bit local cell ID (LCID), a ~~9~~13-bit station ID (SID) and a ~~3~~8-bit flow ID (FID). The LCID uniquely identify a local cell within an MR-WRAN cell that is under the control of the distributed scheduling R-CPE. The SID uniquely identifies a station that is under the control of the BS, the MR-BS or the distributed scheduling R-CPE. A SID can be for a unicast station, when referencing a single CPE, or for a multicast station, when referencing a multicast group (of CPEs). A FID identifies a particular traffic flow assigned to a CPE. A 4bit LSB of FID defines downstream flow ID, while a 4bit MSB of FID defines upstream flow ID. The tuple of LCID, SID and FID (LCID | SID | FID) forms a connection identifier (CID) that identifies a connection for the CPE. The LCID and SID ~~is~~are signaled in the DS/US- MAP allocation, and the FID is signaled in the generic MAC header (GMH) of a MAC PDU. This allows for a total of up to ~~512~~8192 stations in each local cell up to 255, each with a maximum of ~~eight~~ sixteen flows that can be supported within each downstream and upstream channel. LCID with all zero shall be allocated for the WRAN and MR-WRAN cells.

Change the third paragraph as follows:

At CPE initialization, three flows shall be dedicated for management connections (see 12.2) for the purpose of carrying MAC management messages and data between a CPE and the BS/MR-BS or the distributed scheduling R-CPE. The three flows reflect the fact that there are inherently three different levels of QoS for traffic sent on management connections between a CPE and the BS/MR-BS or the distributed scheduling R-CPE. The basic flow is used by the BS/MR-BS MAC or the distributed scheduling R-CPE MAC and CPE MAC to exchange short, time- urgent MAC management messages; whereas, the primary management flow is used by the BS/MR-BS or the distributed scheduling R-CPE MAC and CPE MAC to exchange longer, more delay-tolerant MAC management messages (Table 19 specifies which MAC management messages are transferred on which type of connections). Finally, the secondary management flow is used by the BS/MR-BS or the distributed scheduling R-CPE and CPE to transfer more delay tolerant, standards-based (e.g., DHCP, TFTP, and SNMP) messages that are carried in IP datagrams. The secondary management flow may be packed and/or fragmented, similarly to the primary management except that no ARQ should be used for the latter since it is more time critical.

Change the fourth paragraph as follows:

(Note: Different FID can be set for downstream and upstream in order to support different services for downstream and upstream)

The FIDs for these connections shall be assigned according to the specification in 12.2. ~~The same FID value is assigned to both upstream and downstream members of each connection.~~ A 4-bit LSB of FID defines downstream flow ID, while a 4-bit MSB of FID defines upstream flow ID.

Change the fifth paragraph as follows:

The CID, which is a tuple of LCID | SID | FID, can be considered a connection identifier even for nominally connectionless traffic like IP, since it serves as a pointer to destination and context information.

Change the sixth paragraph as follows:

Many higher-layer sessions may operate over the same wireless connection. For example, many users within a company may be communicating with Transmission Control Protocol (TCP)/IP to different destinations, but since they all operate within the same overall service parameters, all of their traffic is pooled for request/grant purposes. A service flow is a unidirectional flow of traffic (BS/MR-BS to CPE, or CPE to BS/MR-BS, distributed scheduling R-CPE to CPE or CPE to distributed scheduling R-CPE) that defines the mapping of higher-layer application service parameters (e.g., QoS) to a LCID assigned to a particular local cell with a FID assigned to a particular CPE's unicast SID or multicast group (multicast SID).

7.3 General superfame structure

Insert the following paragraph as the first paragraph in section 7.3:

The MR-WRAN supports two PHY modes of PHY mode 1 (Clause 9) and PHY mode 2 (Clause 9a).

The WRAN system and the MR-WRAN system on PHY mode 1 shall support the following superframe structure.

The MR-WRAN on PHY mode 2 does not support the following superframe structure.

Change the paragraph as follows:

The ~~IEEE 802.22~~ WRAN system and the MR-WRAN system on PHY mode 1 include~~s~~ two operational modes: a normal mode and a self-coexistence mode. In normal mode, one WRAN cell occupies one channel or more channels and operates on all the frames in a superframe; while in self-coexistence mode, multiple WRAN and/or MR-WRAN cells share the same channel and each coexisting WRAN~~-~~and/or MR-WRAN cells operates on one or several different frames exclusively.

7.4 General frame structure (on PHY Mode 1)

Insert the following paragraph as the first paragraph in section 7.4:

The WRAN system and the MR-WRAN system on PHY mode 1 described in Clause 9 shall support the following frame structure.

Insert the new subsection 7.4a after section 7.4:

7.4a General frame structure (on PHY Mode 2)

The MR-WRAN on PHY mode 2 described in Clause 9a shall support the following frame structure.

The MR-WRAN on PHY mode 2 includes two operational modes: a normal mode and a self-coexistence mode. In normal mode, one MR-WRAN cell occupies one or more channels and operates on all the frames; while in self-coexistence mode, multiple MR-WRAN cells share the same channel and each coexisting WRAN cell operates on one or several different frames exclusively.

The MR-WRAN on PHY mode 2 shall transmit the Frame Control Header (FCH) (7.5.2a, Table A1) at the beginning of every frame on the operating channel in both normal mode and self-coexistence mode. An MR-WRAN run in normal mode by default and transits to self-coexistence mode when the MR-WRAN can detect and decode an FCH or a CBP from an adjacent MR-WRAN cell on its operating channel.

7.4a.1 General frame structure for normal mode

The MR-WRAN frame structure depicted in Figure 12 shall be used and the first frame shall be constituted of the following:

- A PHY frame preamble, see Clause 9a
- A Frame Control header (FCH), see Clause 7.5.2a
- The rest of the first frame including its frame header and data payload

At the beginning of every frame, the MR-BS shall transmit the frame preamble and the FCH on the operating channel using the modulation/coding specified in 9a.2 and Table E1 respectively. In order to associate with an MR-BS, a CPE must receive the FCH to establish communication with the MR-BS. During each MAC frame, the MR-BS shall manage the upstream and downstream operations, which may include ordinary data communication, measurement activities, coexistence procedures, and so on.

7.4a.2 General frame structure for self-coexistence mode

The MR-WRAN frame structure in self-coexistence mode is shown in Figure A1. The self-coexistence mode is for the scenario when multiple MR-BSs with overlapping coverage have to share the same channel. The frequency reuse factor cannot be maintained as one due to their mutual interference. In this case, these MR-BSs shall share the channel on a per frame basis, i.e., each MR-BS is allocated the frames on a non- interference basis. The negotiation process of frame allocation can be found in 7.20.

In self-coexistence mode, the MR-BS and CPEs in an MR-WRAN cell shall only transmit during the active frames allocated to that MR-WRAN cell. They can only transmit during other frames when a self-coexistence window (SCW) has been scheduled. During the frames not allocated to the present cell, the MR-BS and CPEs may monitor the channel for any transmission from neighboring MR-WRAN cells to improve self-coexistence.

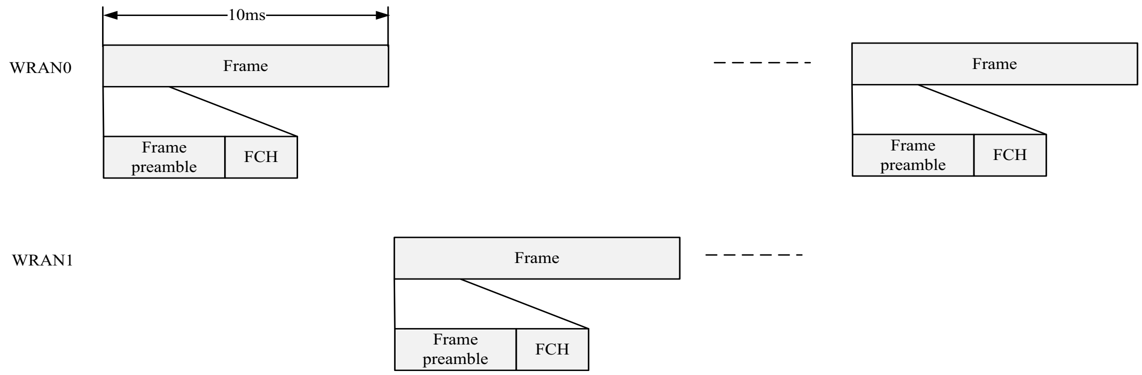

Figure A1—General frame structure on PHY Mode 2 for self-coexistence mode

7.4a.3 Frame format

The MR-WRAN system on PHY mode 2 described in Clause 9a shall support the following frame structure.

The top-down time division duplex (TDD) frame structure employed in the MAC is illustrated in Figure 12.

As illustrated in Figure B1, a frame is comprised of two parts: a downstream (DS) subframe and an upstream (US) subframe. A portion of the US subframe may be allocated as a window to facilitate self- coexistence. This SCW may be scheduled by the MR-BS at the end of the US subframe when necessary to allow transmission of opportunistic coexistence beacon protocol bursts. The SCW includes the necessary time buffers to absorb the difference in propagation delay between close-by and distant MR-BSs and CPEs operating on the same channel. The boundary between the DS and US subframes shall be adaptive to adjust to the downstream and upstream relative capacity. The upstream subframe may contain scheduled upstream PHY PDUs, each transmitted from different CPEs for their upstream traffic. It may also include contention intervals scheduled for the following:

— CPE association (initial ranging)
— CPE link synchronization, power control and geolocation (periodic ranging)
— Bandwidth request
— Urgent coexistence situation (UCS) notification
— Quiet period resource adjustment

The definitions of the fields/messages are given in 7.6 and 7.7.

The PHY PDUs may be transmitted across several subchannels as shown in Figure B1, which depicts how a frame may be transmitted (in time and frequency) by the PHY layer.

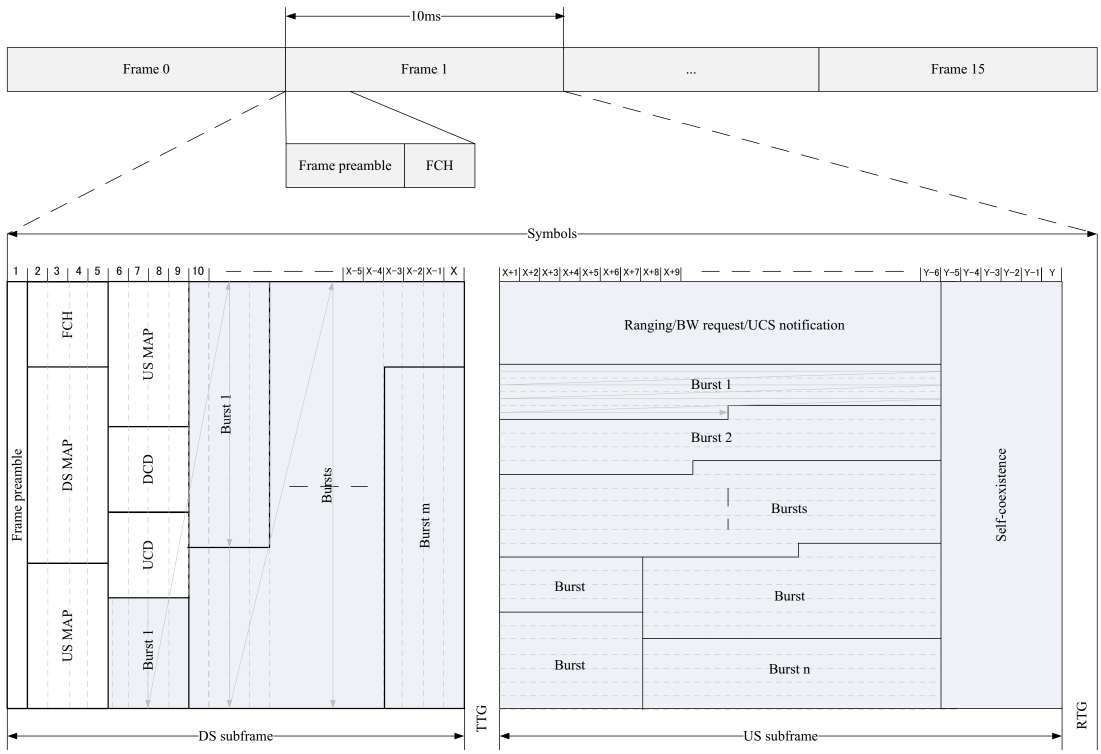

Figure B1—Example of a time/frequency structure of a MAC frame for PHY Mode 2

Figure B1 shows an example of the two-dimensional (time/frequency) structure of the MAC frame that shall consist of an integer number of fixed size OFDM slots. Each slot shall consist of 4 OFDM symbols by one subchannel (i.e., 1 OFDM slot for DS = 4 symbols × 1 subchannel) for downstream, while shall consist of 7 OFDM symbols by subchannel (i.e., 1 OFDM slot for US= 7 symbols × 1 subchannel) for upstream (9a.1.3.1, tile, slot and data region). A subchannel consists of 16 subcarriers. To help understand Figure B1, the MAC packets are assumed to be structured in a linear TDM manner (see Figure 12), while the PHY packets are arranged in a two-dimensional time/frequency domain (symbol in the horizontal direction, logical subchannels in the vertical direction). For the FCH, the DS/US-MAP, the DCD, and UCD, as well as for the downstream payload, the MAC information is first laid vertically by subchannels then stepped horizontally in the time direction. This vertical layering allows early scheduling of DS bursts assigned to distant CPEs to compensate for propagation delays and to avoid potential interference at the CPE in the case of overlapping MR-WRAN cells with different DS/US capacity split.

The MAC data elements, starting from the FCH and including the first broadcast burst, shall be entered into the portion between the second OFDM symbol and fifth OFDM symbol, which is based on the number of symbols defined in a tile (9a.1.3.1, tile, slot and data region), as shown in Figure B1, in the increasing order of logical subchannels until all logical subchannels are occupied. Then, the subsequent data elements, if they have not all been mapped, shall be placed in the same order on the following OFDM symbols. The balance of the last OFDM symbols shall be padded with zeros. The modulation and coding schemes for the padding zeros are defined by the DIUC for the last DS burst in the DS-MAP. Note that the DS-MAP indicates the length of the contiguous DS MAC elements, not their absolute position in the DS subframe.

The MAC data elements that are contained in upstream bursts shall be mapped to the US subframe in a different order as shown in Figure B1. They are first mapped horizontally, 7 OFDM symbols by 7 OFDM symbols, in the same logical subchannel. Once a logical subchannel has been filled to the end of the upstream subframe, the balance of the MAC data elements shall be mapped to the next logical subchannel, in an increasing subchannel order. This process continues until all of the subchannels and symbols allocated to the burst are filled. If the quantity of MAC data elements is insufficient to fill an upstream burst so that an integer number of OFDMA slots is occupied once encoded, zero padding shall be inserted at the end.

Alternatively, the horizontal laying of the MAC data elements may fill one subchannel with at least 7 OFDM symbols at a time and continue on the following subchannels. However, when all logical subchannels have been filled, the next MAC data elements shall be placed in the first available logical subchannel in the following burst. The width of the last vertical burst will be between 7 and 13 symbols depending on the total number of symbols in the upstream subframe.

The long upstream packet structure, where a logical subchannel is completely filled before moving to the next subchannel, is used to maximize the allowed power per subcarrier for a given CPE EIRP limit, i.e., this horizontal laying reduces the EIRP required by the CPE for its upstream burst by minimizing the number of subchannels needed. In the upstream, the shorter burst alternative shown in Figure B1 is used to reduce latency by allowing advance of the US burst in the US subframe to give the base station time to react before the start of the next frame, at the cost of reduced transmit power and efficiency (e.g., video game near real-time versus transmission efficiency).

The format of the FCH MAC burst is described in 7.5.2a. The FCH is modulated using the data mode selected (e.g., Mode 2, see Table E1). Binary convolutional coding (9a.7.2.1) shall also be applied to the FCH burst. The FCH specifies the burst profile and the length of either the DS-MAP, if transmitted, or the US-MAP. If neither, the DS-MAP nor the US-MAP is transmitted, the value shall be set to zero. The DS-MAP message, if transmitted, shall be the first MAC PDU in the burst following the FCH. A US-MAP message, if transmitted, shall immediately follow either the DS-MAP message, if transmitted, or the FCH. If DCD and UCD messages are transmitted in the frame, they shall immediately follow the DS-MAP and US-MAP messages. The symbols containing these broadcast MAC control messages shall be modulated using data mode 2 as described in Table E1 with the mandatory BCC mode (see 9a.7.2.1).

In the upstream direction, if a CPE does not have any data to transmit in its US allocation, it shall transmit an US PHY burst containing a generic MAC header (see 7.6.1.1) with its basic FID, together with a Bandwidth Request subheader (see 7.6.1.2.1). This would allow the MR-BS to reclaim this CPE's allocation in the following frames and use the resource for some other purpose.

The MR-BS may schedule up to five types of contention windows (see 7.13): the Initial Ranging window is used for initializing the association; the periodic ranging window is used for regularly adjusting the timing and power at the CPE; the BW request window is for CPEs to request upstream bandwidth allocation from the MR-BS; the UCS notification window is used by CPEs to report an urgent coexistence situation with incumbents; while the SCW is employed by CBP packets for signaling information to adjacent and overlapping MR-WRAN cells for the purpose of self-coexistence, signal the device identification for resolving interference situations with incumbents when requested by local regulation, and for carrying out terrestrial geolocation between CPEs of the same MR-WRAN cell. However, CBP burst transmissions for terrestrial geolocation purpose shall have lower priority than any other coexistence transmission on the CBP burst.

The SCW shall be scheduled at the end of the frame as depicted in Figure B1. The CBP packets are transmitted by selected CPEs or the MR-BS, and carry information, among other things, about the IEEE 802.22b cell as a whole, the device that transmits it, as well as information to support the self-coexistence mechanism (see 7.20).

A CBP packet shall be transmitted by each CPE associated to a MR-BS as specified by the parameter "T34" in Table 272 for periodic identification of its device ID and serial number and the associated base station ID as may be required by local regulations (see Annex A).

Whenever a CPE is neither receiving nor sending data to its MR-BS (idle state), it shall be capable of decoding CBP packets transmitted by nearby CPEs belonging to other MR-WRAN cells, either on the same channel (N), or on adjacent channels (N±1), or on alternate channels (N±2 and beyond). This capability shall also be available at CPE initialization. In addition, MR-BS frame synchronization is based on the absolute local start time of their frame period to the start of every minute referenced to UTC as specified in 7.23. Hence, multiple co-located or nearby MR-BS cells can efficiently communicate with each other and align their SCW for CBP exchange as well as their quiet periods for sensing incumbents.

Insert the new subsection 7.4b after section 7.4a:

7.4b General frame structure for a relay network

The MR-WRAN system on the both PHY mode 1 and 2 shall support the following frame structure for relay.

A general frame structure has two different modes for relay: a centralized relay mode and a distributed relay mode. On the centralized relay mode, a centralized scheduling R-CPE provides relay connections for the S-CPEs under the management of the MR-BS. On the distributed relay mode, on the other hand, a distributed scheduling R-CPE configures a local cell within the MR-WRAN cell, and has the similar functionality of MR-BS and manages S-CPEs within the local cell.

7.4b.1 General frame structure for a centralized relay mode

Each of the downstream and upstream subframes for a centralized relay mode may include two zones: access zone (AZ) and centralized relay zone (CRZ) as shown in Figure C1. Each AZ in the downstream and upstream subframes is used for transmission between an MR-BS and CPEs (i.e., centralized scheduling R-CPEs or S-CPEs), while each CRZ in the downstream and upstream subframes is used for transmission between a centralized scheduling R-CPE and S-CPEs.

For a centralized scheduling mode, both of AZs and CRZs in the downstream and upstream subframes are managed by an MR-BS.

7.4b.2 General frame structure for a distributed relay mode

Each of the downstream and upstream subframes for a distributed relay mode may include two zones: access zone (AZ) and distributed relay zone (DRZ) as shown in Figure D1. Each AZ in the downstream and upstream subframes is used for transmission between an MR-BS and CPEs (distributed scheduling R-CPEs or S-CPEs), while each DRZ in the downstream and upstream subframe is used for transmission between a distributed scheduling R-CPE and S-CPEs.

The both of AZs and DRZs in the downstream and upstream subframes are scheduled by an MR-BS. For a distributed relay mode, the AZs in the downstream and upstream subframes are managed by an MR-BS, while the DRZs in the downstream and upstream subframes are controlled by a distributed scheduling R-CPE, which is capable of configuring and maintaining a local cell within an 802.22b MR-WRAN cell.

For the IEEE 802.22b MR-WRAN on PHY mode 2, the subchannels of the DRZs in the downstream and upstream subframes can be grouped by 3 segments with the same number of subchannels as shown in Figure E1. The segmentation can be scheduled by the MR-BS, and each segment is assigned to the different distributed scheduling R-CPEs. This segmentation is used to increase network capacity.

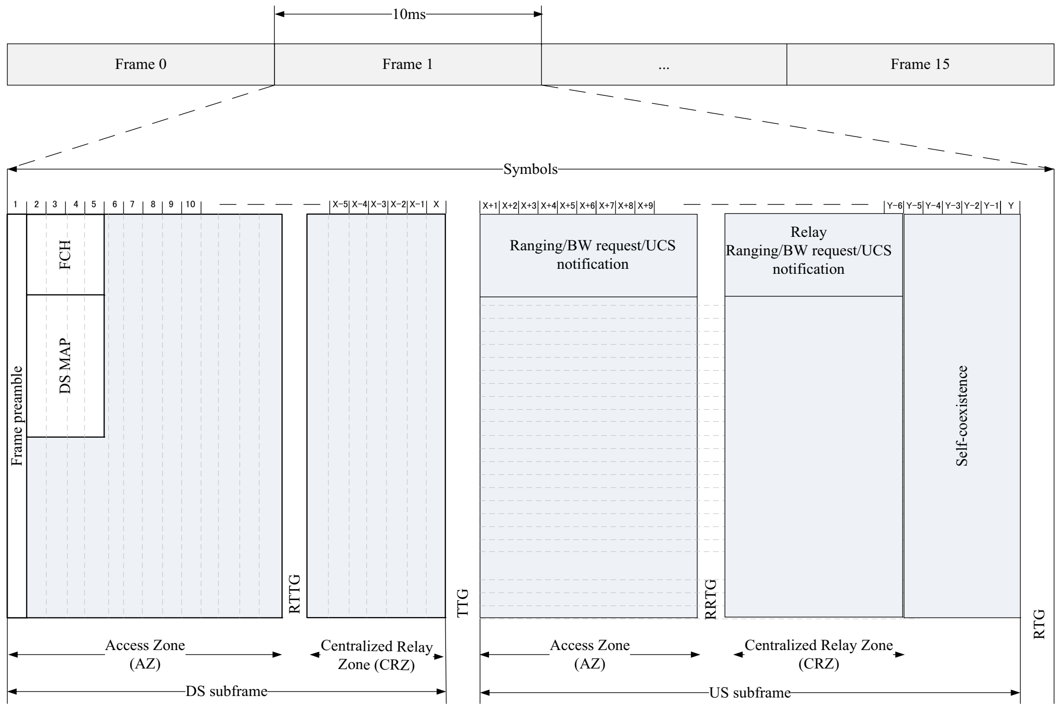

Figure C1—<u>Example of a time/frequency structure of a MAC frame for a centralized relay mode on PHY mode 2</u>

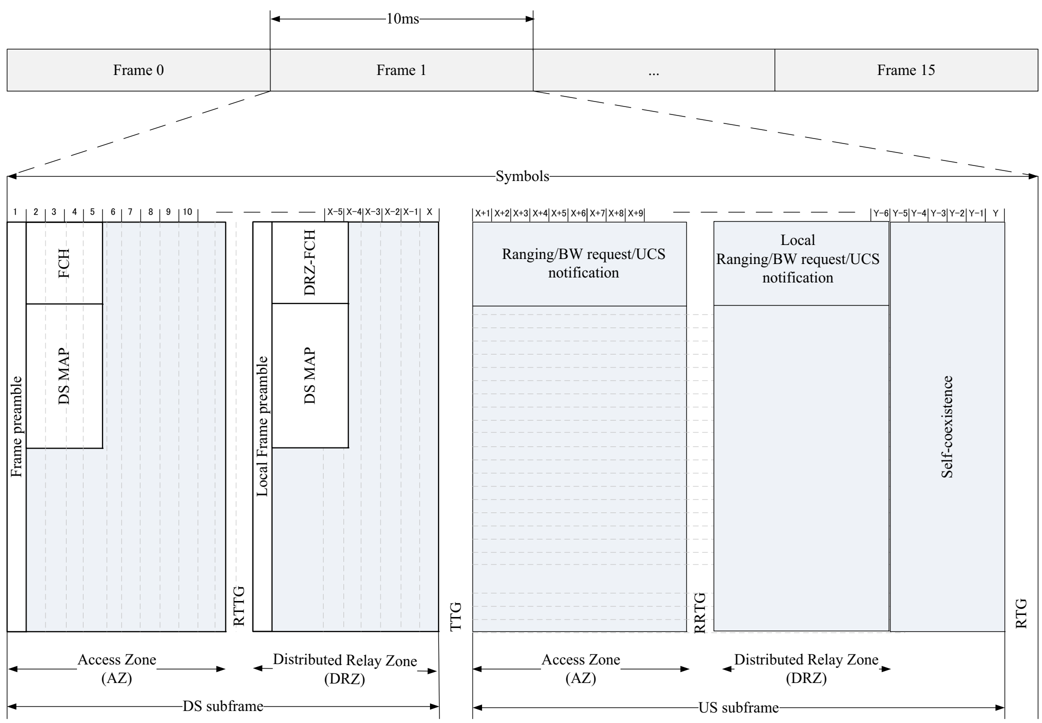

Figure D1—<u>Example of a time/frequency structure of a MAC frame for a distributed relay mode on PHY mode 2</u>

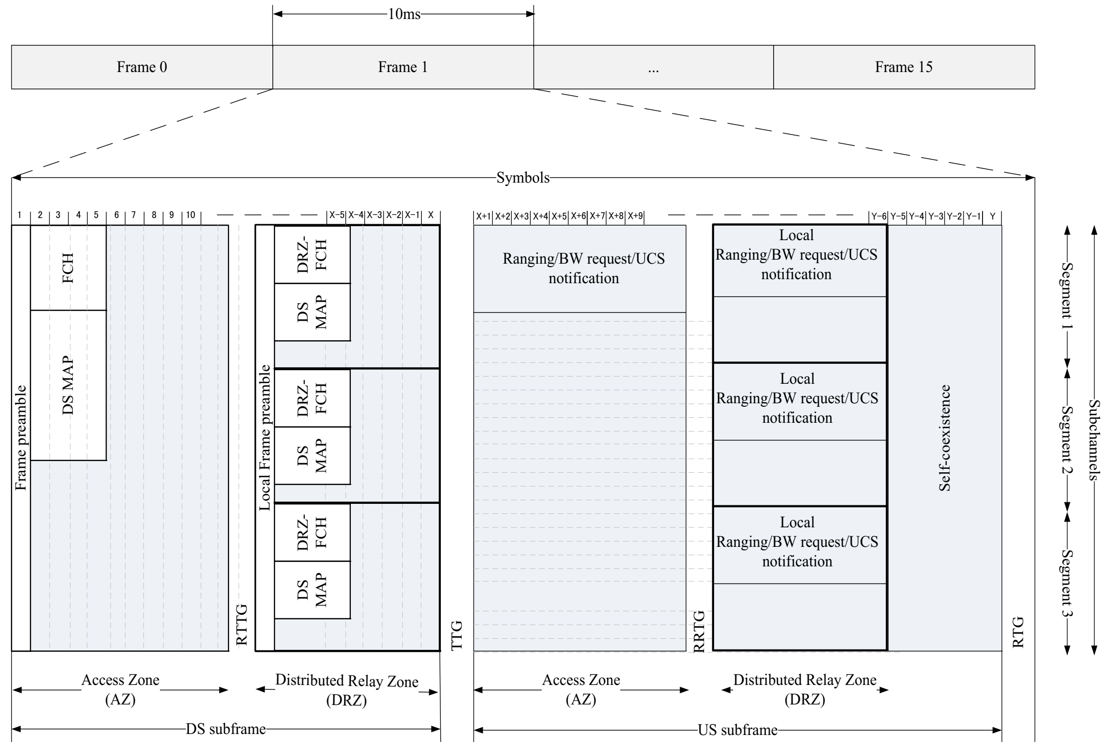

Figure E1—Example of a time/frequency structure of a MAC frame for a distributed relay mode on segmentation on PHY mode 2

7.4b.3 Detail of Zones

7.4b.3.1 Access Zone (AZ)

At the beginning of every frame in AZ, the MR-BS shall transmit the frame preamble and the FCH on the operating channel using the modulation/coding specified in 9a.2 and Table E1 respectively. In order to associate with an MR-BS, a CPE must receive the FCH to establish communication with the MR-BS.

An AZ in the upstream subframe may contain scheduled upstream PHY PDUs, each transmitted from different CPEs for their upstream traffic. It may also include contention intervals scheduled for the following:

- CPE association (initial ranging)
- CPE link synchronization, power control and geolocation (periodic ranging)
- Bandwidth request
- Urgent coexistence situation (UCS) notification
- Quiet period resource adjustment

The two-dimensional (time/frequency) structure of the MAC frame shall consist of an integer number of fixed size OFDM slots. For PHY mode 1, each slot shall consist of one OFDM symbol by one subchannel (i.e., 1 OFDM slot = 1 symbol × 1 subchannel) for both downstream and upstream. For PHY mode 2, on the other hand, each slot shall consist of 4 OFDM symbols by one subchannel (i.e., 1 OFDM slot for DS = 4 symbols × 1 subchannel) for downstream, while shall consist of 7 OFDM symbols by subchannel (i.e., 1 OFDM slot for US= 7 symbols × subchannel) for upstream (9a.1.3.1, tile, slot and data region). For the FCH, the DS/US-MAP, the DCD, the UCD, as well as for the downstream payload in an AZ, the MAC information is first laid vertically by subchannels then stepped horizontally in the time direction. This vertical layering allows early scheduling of DS bursts assigned to distant CPEs to compensate for propagation delays and to avoid potential interference at the CPE in the case of overlapping MR-WRAN cells with different DS/US capacity split.

In an AZ, the MAC data elements, starting from the FCH and including the first broadcast burst, shall be mapped to the DS subframe as the same manner described in 7.4 for PHY mode 1 and 7.4a.3 for PHY mode 2.

In an AZ, the MAC data elements that are contained in upstream bursts shall be mapped to the US subframe as the same manner described in 7.4 for PHY mode 1 and 7.4a.3 for PHY mode 2.

7.4b.3.2 Centralized Relay Zone (CRZ)

During a CRZ in the DS subframe, the centralized scheduling R-CPE transmits the MAC frames, which are transferred from the MR-BS during an AZ in the downstream subframe, to the S-CPE on the scheduled slots determined by the MR-BS.

A CRZ in the upstream subframe may contain scheduled upstream PHY PDUs, each transmitted from different S-CPEs for their upstream traffic, which forwards the centralized scheduling R-CPE. It may also include contention intervals scheduled for the following:

- CPE relay association (relay initial ranging 7.15.2)
- CPE relay power control and geolocation (relay periodic ranging 7.15.2)
- Relay bandwidth request
- Relay urgent coexistence situation (UCS) notification
- Quiet period resource adjustment

The two-dimensional (time/frequency) structure of the MAC frame in a CRZ is the same manner as that in an AZ (7.4b.3.1).

If a CRZ is appeared in the downstream subframe, the CRZ shall be appeared followed by the downstream AZ in the MAC frame. The MAC data bursts in the CRZ shall be entered into the first subchannel within the portion, calculated by CRZ Start Offset and Length in CRZDS-MAP IE (7.7.2.3), in the increasing order of logical subchannels until all logical subchannels are occupied in the portion. Then, the subsequent data elements if they have not all been mapped, shall be placed in the same order on the following OFDM symbols. The balance of the last OFDM symbols within the portion shall be padded with zeros. The modulation and coding schemes for the padding zeros are defined by the DIUC for the last DS burst in CRZDS-MAP IE.

If a CRZ is appeared in the upstream subframe, the MAC data elements that are contained in relay upstream bursts shall be mapped to the CRZ in the US subframe in the same manner of US subframe mapping in AZ (7.4b.3.1).

The MR-BS may schedule up to four types of contention windows (see 7.13) in the CRZ: the relay initial ranging window is used for initializing the relay association; the relay periodic ranging window is used for regularly adjusting the timing and power at the CPE; the relay BW request window is for CPEs to request relay upstream bandwidth allocation from the MR-BS; the relay UCS notification window is used for CPEs to report an urgent coexistence situation with incumbents.

7.4b.3.3 Distributed Relay Zone (DRZ)

For local cell operations within an 802.22b MR-WRAN, the MR-BS will schedule a DRZ for a distributed scheduling R-CPE, which is capable of managing a local cell. During a DRZ, the distributed scheduling R-CPE shall transmit the local frame preamble and the DRZ-FCH (7.5.2b) on the operating channel using the modulation/coding specified in 9.2 and Table 202 for PHY mode 1 and 9a.2 and Table E1 for PHY mode 2, respectively. In order to associate with the distributed scheduling R-CPE, a S-CPE must receive the DRZ-FCH to establish communication with the distributed scheduling R-CPE. During each DRZ in the downstream and upstream subframes, the distributed scheduling R-CPE shall manage the upstream and downstream operations within its local cell, which may include ordinary data communication, measurement activities, coexistence procedures, and so on.

A DRZ in the upstream subframe may contain scheduled upstream PHY PDUs, each transmitted from different CPEs for their upstream traffic to the distributed scheduling R-CPE. It may also include contention intervals scheduled for the following:

— CPE local association (local initial ranging)
— CPE local link synchronization, power control and geolocation (local periodic ranging)
— Local bandwidth request
— Local urgent coexistence situation (UCS) notification
— Quiet period resource adjustment

The two-dimensional (time/frequency) structure of the MAC frame in a DRZ is the same manner as that in an AZ (7.4b.3.1).

If a DRZ is appeared in the downstream subframe, the DRZ shall be appeared followed by the downstream AZ in the MAC frame. The MAC data elements that are contained in downstream bursts shall be mapped to the DRZ in the DS subframe in the same manner of the AZ in DS subframe mapping.

If a DRZ is appeared in the upstream subframe, the DRZ shall be appeared followed by the upstream AZ in the MAC frame. The MAC data elements that are contained in upstream bursts shall be mapped to the DRZ in the US subframe in the same manner of the AZ in US subframe mapping (7.4b.3.1).

The format of the DRZ-FCH MAC burst is described in 7.5.2b. The DRZ-FCH is modulated using the data mode selected. Binary convolutional coding (BCC, 9a.7.2.1) shall also be applied to the DRZ-FCH burst. The DRZ-FCH specifies the burst profile and the length of either the DS-MAP, if transmitted, or the US-MAP. If neither, the DS-MAP nor the US-MAP is transmitted, the value shall be set to zero. The DS-MAP message, if transmitted, shall be the first MAC PDU in the burst following the DRZ-FCH. A US-MAP message, if transmitted, shall immediately follow either the DS-MAP message, if transmitted, or the DRZ-FCH. If DCD and UCD messages are transmitted in the frame, they shall immediately follow the DS-MAP and US-MAP messages. The symbols containing these broadcast MAC control messages shall be modulated using data mode 5 as described in Table 202 for PHY mode 1 or data mode 3 as described in Table E1 for PHY mode 2 with the mandatory BCC mode (see 9.7.2.1).

The distributed scheduling R-CPE may schedule up to four types of contention windows (see 7.13): the local Initial Ranging window is used for initializing the association; the local periodic ranging window is used for regularly adjusting the timing and power at the CPE; the local BW request window is for CPEs to request local upstream bandwidth allocation from the dirstibuted scheduling R-CPE; the local UCS notification window is used by CPEs to report an urgent coexistence situation with incumbents.

7.5 Control header

7.5.2 Frame Control header

Insert the new subsection 7.5.2a after section 7.5.2:

7.5.2a Frame control header for PHY mode 2

The format of the FCH for PHY mode 2 is shown in Table A1. Since FCH decoding is critical, the FCH shall be encoded using either the modulation specified by the PHY mode 2 as described in Table E1. The FCH contains the length of either the DS-MAP or US-MAP that immediately follows the FCH (note that Length = 0 indicates the absence of any burst in the frame). In the case where the DS-MAP is specified, the US-MAP length information shall be contained in the first DS-MAP information element. In the case where the US-MAP length is indicated in the FCH, there shall be no DS burst in the current frame. DCD and UCD messages, if present, are carried by the next DS bursts specified by the DS-MAP. Location and profile of the data bursts are specified in the rest of the DS-MAP and US-MAP management messages. A HCS field occupies the last byte of the FCH.

Table A1—Frame control header format for PHY mode 2

Syntax	Size	Note
Frame_Control_Header_Format() {		
MR-BS ID	48 bits	MAC address that uniquely identifies the BS transmitting the FCH.
Length of the frame	6 bits	Indicates the length of the frame in number of OFDM symbols from the start of the frame including all preambles.
Length of the MAP message	10 bits	This field specifies the length of the MAP information element following the FCH in OFDM slots. A length of 0 (zero) indicates the absence of any burst in the frame.
Frame Number	8 bits	Positive integer that represents the frame number (modulo 256). This field shall be incremented by 1.
CP	2 bits	Cyclic Prefix Factor Specifies the size of the cyclic prefix used by the PHY in the frame transmissions in this frame. Pre-determined values are 00: 1/4 TFFT 01: 1/8 TFFT 10: 1/16 TFFT 11: 1/32 TFFT
Self-coexistence Capability Indicator	4 bits	0000: no self-coexistence capability supported 0001: only Spectrum Etiquette 0010: Spectrum Etiquette and Frame Contention 0011–1111: Reserved

Table A1—Frame control header format for PHY mode 2

Syntax	Size	Note
Extended FCH	2 bits	00: No Extended FCH 01: Extended FCH appears following this FCH 10-11: Reserved
MAC version	8 bits	IEEE 802.22 MAC version to which the message originator conforms. 0x01: IEEE Std 802.22 0x02: IEEE Std 802.22b 0x03–0xFF: Reserved
HCS	8 bits	Header Check Sequence See Table 3.
}		

Insert the new subsection 7.5.2a.1 as follows:

7.5.2a.1 Extended Frame control header (Ex-FCH)

The Ex-FCH specification is shown in Table B1. The Ex-FCH decoding is the same as FCH. TheEx-FCH provides information about the MR-WRAN cell, in order to protect incumbents, support self-coexistence mechanisms, and support the intra- frame and inter-frame mechanisms for management of quiet periods for sensing.

Table B1—Extended frame control header format

Syntax	Size	Notes
Extended_FCH_Format() {		
Length	8 bits	Length of Extended FCH
Current Intra-frame Quiet Period Cycle Length	8 bits	Specified in number of frames, it indicates the spacing between the frames for which the intra-frame quiet period specification is valid. For example, if this field is set to 1, the Quiet Period Cycle repeats every frame; if it is set to 2, the Quiet Period Cycle repeats every 2 frames, etc. If this field is set to 0, no intra-frame quiet period is scheduled or the current intra-frame quiet period is canceled.
Current Intra-frame Quiet Period Cycle Offset	8 bits	Valid only if Current Intra-frame Quiet period Cycle Length > 0. Specified in number of frames, it indicates the offset from this Extended FCH transmission to the beginning of the first frame in the Current Intra- frame Quiet period Cycle Length.

Table B1—Extended frame control header format

Syntax	Size	Notes
Current Intra-frame Quiet period Cycle Frame Bitmap	16 bits	Valid only if Current Intra-frame Quiet Period Cycle Length > 0. Valid for each frame identified by the Current Intra-frame Quiet Period Cycle Length, each bit in the bitmap corresponds to one frame within the frame. If the bit is set to 0, no intra-frame quiet period shall be scheduled in the corresponding frame. If the bit is set to 1, an intra-frame quiet period shall be scheduled within the corresponding frame for the duration specified by the Current Intra-frame Quiet period Duration.
Current Intra-frame Quiet Period Duration	8 bits	Valid only if Current Intra-frame Quiet Period Cycle Length > 0. If this field is set to a value different from 0 (zero), it indicates the number of symbols starting from the end of the frame during which no transmission shall take place.
Claimed Intra-frame Quiet Period Cycle Length	8 bits	Specified in number of frames, it indicates the spacing between the frames for which the intra-frame quiet period specification claimed by an MR-BS would be valid. For example, if this field is set to 1, the Quiet Period Cycle would repeat every frame; if it is set to 2, the Quiet Period Cycle would repeat every 2 frames, etc. If this field is set to 0, no intra-frame quiet period is claimed by the MR-BS.
Claimed Intra-frame Quiet Period Cycle Offset	8 bits	Valid only if Claimed Intra-frame Quiet Period Cycle Length > 0. Specified in number of frames, it indicates the offset from this Extended FCH transmission to the time where the Claimed Quiet Period Cycle resulting from the inter-BS negotiation (see 7.21.2) shall become the Current Intra- frame Quiet Period Cycle.
Claimed Intra-frame Quiet period Cycle Frame Bitmap	16 bits	Valid only if Claimed Intra-frame Quiet Period Cycle Length > 0. Valid for each frames identified by the Claimed Intra-frame Quiet Period Cycle Length, each bit in the bitmap corresponds to one frame within each specified frame. If the bit is set to 0, no intra-frame quiet period will be scheduled in the corresponding frame. If the bit is set to 1, an intra-frame quiet period will be scheduled within the corresponding frame for the duration specified by Claimed Intra-frame Quiet period Duration.
Claimed Intra-frame Quiet Period Duration	8 bits	Valid only if Claimed Intra-frame Quiet Period Cycle Length > 0. If this field is set to a value different from 0 (zero): it indicates the number of symbols starting from the end of the frame during which no transmission will take place.

Table B1—Extended frame control header format

Syntax	Size	Notes
Synchronization Counter for Intra-frame Quiet Period Rate	8 bits	Valid only if Claimed Intra-frame Quiet Period Cycle Length > 0. This field is used for the purpose of synchronizing the Claimed Intra- frame Quiet Period rate among overlapping MR-BSs in order to allow dynamic reduction of the Intra-frame Quiet Period rate. This Quiet Period rate is defined as the number of frames with quiet periods identified by the Cycle Frame Bitmap in the frames designated by the Cycle Length, divided by this Quiet Period Cycle Length (see 7.21.2).
Synchronization Counter for Intra-frame Quiet Period Duration	8 bits	Valid only if Claimed Intra-frame Quiet Period Duration > 0. This field is used for the purpose of synchronizing the Claimed Intra- frame Quiet Period Durations among overlapping MR-BSs in order to allow dynamic reduction of the Intra-frame Quiet Period Duration (see 7.21.2).
Inter-frame Quiet Period Duration	4 bits	Duration of Quiet Period It indicates the duration of the next scheduled quiet period in number of frames. If this field is set to a value different from 0 (zero), it indicates the number of frames that shall be used to perform in-band inter-frame sensing.
Inter-frame Quiet Period Offset	12 bits	Time to Quiet Period It indicates the time span between the transmission of this information and the next scheduled quiet period for in-band inter-frame sensing. The 8 left most bits (MSB) indicate the frame number and the 4 right most bits (LSB) indicate the frame number when the next scheduled quiet
SCW Cycle Length	8 bits	Specified in number of frames. If this field is set to 0, then no SCW cycle is scheduled. This field has to be 1 or larger to be effective. To limit the number of possibilities, the field shall be one of five following choices {1, 2, 4, 8, 16}. For example, if this field is set to 1, SCW Cycle repeats every frame, if it is set to 2, SCW Cycle repeats every 2 frames, etc.
SCW Cycle Offset	8 bits	Specified in number of frames, it indicates the offset from this Extended FCH transmission to the frame where the SCW cycle starts, or repeats (i.e., the frame contains SCWs and is specified by the SCW Cycle Frame Bitmap). For example, if this field is set to 0, the SCW cycle starts from the current frame.

Table B1—Extended frame control header format

Syntax	Size	Notes
SCW Cycle Frame Bitmap	32 bits	Valid for a unit of frame, each 2-bit in the bitmap corresponds to one frame within the frame. If the 2-bit is set to 00, this means that there is no SCW scheduled for this frame. If the 2-bit is set to 11, a reservation-based SCW (reserved by the current WRAN) is scheduled in the corresponding frame. If the 2-bit is set to 10, a reservation-based SCW has been scheduled by a direct-neighbor WRAN cell in the corresponding frame and needs to be avoided by other WRAN cells receiving this Extended FCH. If the 2-bit is set to 01, a contention-based SCW (that could be shared with other WRANs) is scheduled by the current WRAN cell in the corresponding frame. The number of reservation-based SCWs cannot exceed 2 per WRAN cell per SCW Cycle. At least one contention-based SCW shall be scheduled in one SCW Cycle (code 01). The MR-BSs shall start scheduling their contention-based SCWs from the last frame of the frame, going backward for multiple contention-based SCWs. This bitmap applies only to the frames scheduled by the SCW Cycle. NOTE—Quiet period scheduling should be done prior to the SCW scheduling so that SCWs avoid frames already reserved for QP. If SCW conflicts with QP, QP overrides the SCW.
Current DS/US Split	6 bits	Effective start time (in OFDM symbols from the start of the frame including all preambles) of the first symbol of the upstream allocation when an MR-BS-to-MR-BS interference situation has been identified by direct reception of this parameter by an MR-BS from a Extended FCH or a CBP burst transmitted by another MR-BS. The Allocation Start Time as provided in the US-MAP (see Table 34) shall be equal to this value if MR-BS-to-MR-BS interference has been identified. This value shall be set to zero if no MMR-BS- to-MR-BS interference has been identified (i.e., MR-BS has not received this parameter from another MR-BS). In this case, the Allocation Start Time in the US-MAP (see Table 34) can be defined independently on a frame-by- frame basis by the respective MR-BSs based on their traffic requirement.
Claimed US/DS Split	6 bits	Specified by each MR-BS in the case of MR-BS-to-MR-BS interference (i.e., when Extended FCH and/or CBP burst can be received by an MR-BS directly from another MR-BS) indicating the required DS/US split based in the traffic requirement of the transmitting MR-BS and the negotiation process between the MR-BSs (see 7.20.3). This value shall be set to zero if no MR-BS-to-MR-BS interference has been identified.

Table B1—Extended frame control header format

Syntax	Size	Notes
DS/US Change Offset	12 bits	It indicates the time span between the transmission of this information and the next scheduled change of the DS/US split where the "Claimed DS/US split" value will become the "Current DS/US split" value. The 8 left most bits (MSB) indicate the frame number and the 4 right most bits (LSB) indicate the frame number when the next DS/US split change shall take place. The value of this parameter is determined by the negotiation process between concerned MR-BSs (see 7.20.3). This value shall be set to zero if no MR-BS-to-MR-BS interference has been identified.
Incumbent detection reporting inhibit timer	32 bits	In the case where the BS is informed by the database service that it can continue operating on the current channel even though its CPEs are repetitively reporting an incumbent detection situation (i.e., on N or N±1), the MR-BS can use this parameter to inhibit such reporting by the CPEs for a specified period of time. This will avoid the CPEs flooding the upstream subframe with unnecessary incumbent detection reports. Bit 0–4: Signal type (see Table 237) Bit 5–31: Inhibit Period (number of frames)
HCS	8 bits	Header Check Sequence See Table 3.
}		

Insert the new subsection 7.5.2b as follows:

7.5.2b Distributed Relay Zone (DRZ) Frame Control header (DRZ-FCH)

The DRZ-FCH is used in a DRZ for a distributed relay mode. The format of the DRZ-FCH is shown in Table C1. The DRZ-FCH shall have the same encoding as the FCH in each mode of PHY mode 1 or PHY mode 2. The DRZ-FCH contains the length of either the DS-MAP or US-MAP that immediately follows the DRZ-FCH (note that Length = 0 indicates the absence of any burst in the frame). In the case where the DS-MAP is specified, the US-MAP length information shall be contained in the first DS-MAP information element. In the case where the US-MAP length is indicated in the DRZ-FCH, there shall be no DS burst in the current frame. DCD and UCD messages, if present, are carried by the next DS bursts specified by the DS-MAP. Location and profile of the data bursts are specified in the rest of the DS-MAP and US-MAP management messages. A HCS field occupies the last byte of the DRZ-FCH.

Table C1—DRZ Frame control header format (DRZ-FCH)

Syntax	Size	Notes
DRZ Frame_Control_Header_-Format() {		

Table C1—DRZ Frame control header format (DRZ-FCH)

Syntax	Size	Notes
Distributed Scheduling R-CPE ID	48 bits	MAC address that uniquely identifies the BS transmitting the DRZ-FCH.
Length of the DRZ MAP message	10 bits	This field specifies the length of the DRZ MAP information element following the FCH in OFDM slots. A length of 0 (zero) indicates the absence of any burst in the frame.
Frame Number	8 bits	This field is same at the frame number indicated in FCH (Table 2)
CP	2 bits	Cyclic Prefix Factor Specifies the size of the cyclic prefix used by the PHY in the frame transmissions in this frame. Pre-determined values are 00: 1/4 TFFT 01: 1/8 TFFT 10: 1/16 TFFT 11: 1/32 TFFT
MAC version	8 bits	This field is same at the MAC version indicated in FCH
HCS	8 bits	Header Check Sequence. See Table 3.
}		

7.6 MAC PDU formats

7.6.1 MAC headers

7.6.1.1 Generic MAC header

Change the size of Type in Table 3 as follows:

Table 3—Generic MAC header format

Syntax	Size	Notes
Type	~~5~~6 bits	Indicates the subheaders and special payload types present in the message payload. See Table 4

Insert new items in Table 4 as follows:

Table 4—Encoding of the Type field

Type bit	Values
6	Channel Aggregation subheader Indicates whether the Channel Aggregation subheader is presented (see Table E1) 1: present; 0: absent
5	Extended Bandwidth Request subheader Indicates whether this is an Extended bandwidth request frame, and hence contains a special payload related to bandwidth allocation (see Table D1) 1: present; 0: absent
4	Bandwidth Request subheader Indicates whether this is a bandwidth request frame, and hence contains a special payload related to bandwidth allocation (see Table 5) 1: present; 0: absent
3	ARQ feedback payload 1: present; 0: absent
2	Extended type Indicates whether the present Packing or Fragmentation subheader is extended 1: Extended 0: not Extended. Applicable to connections where ARQ is not enable
1	Fragmentation/Packing subheader 1: present; 0: absent

7.6.1.2 MAC subheaders and special payloads

Change the first paragraph as follows:

Five types of subheaders may be present. The per-PDU subheaders (i.e., Bandwidth Request, Fragmentation/Packing, Grant Management, Extended Bandwidth Request, Channel Aggregation) may be inserted in MAC PDUs immediately following the generic MAC header. If indicated, the Bandwidth Request subheader and Extended Bandwidth Request subheader shall always follow the Generic MAC header. In the upstream, if both the Grant Management subheader and Fragmentation/Packing subheader are indicated, the Grant Management subheader shall come first. If both the Grant Management subheader and Bandwidth Request subheader are indicated, the Grant Management subheader shall come first.

7.6.1.2.1 Bandwidth Request subheader

Insert the new subsection 7.6.1.2.1a after section 7.6.1.2.1:

7.6.1.2.1a Extended Bandwidth Request subheader

Extended Bandwidth Request subheaders are transmitted by the centralized scheduling R-CPE to the MR-BS to request additional bandwidth for a CRZ connection. They shall be sent in a PDU by itself or in a PDU with other subheaders and/or data. (See Table D1).

Table D1—Extended Bandwidth Request subheader format

Syntax	Size	Notes
BW_ Request_Subheader_Format() {		
Number of BR CPEs ; n	8 bits	The number of CPEs, which require bandwidth request
For (i=1; i<= n; i++){	Variable	
CPE MAC address	48 bits	MAC address of CPE, which require bandwidth request. This is used in initial ranging
SID	13 bits	SID of CPE, which require bandwidth request
Directions	2 bits	0: upstream 1: downstream 2: both of upstream and downstream
If(Directions =0 or 2) {		
uFID	8 bits	Flow ID for upstream
Type	1 bit	Indicates the type of the bandwidth request adjustment 0: incremental 1: aggregate
BR	20 bits	The number of bytes of upstream bandwidth requested by the CPE. The request shall not include any PHY overhead.
}		
Else if (Directions = 1 or 2) {		
dFID	8 bits	Flow ID for downstream
Type	1 bit	Indicates the type of the bandwidth request adjustment 0: incremental
BR	20 bits	The number of bytes of upstream bandwidth requested by the CPE. The request shall not include any PHY overhead.
}		
}		
}		

7.6.1.2.5 Channel aggregation subheader

The format of channel aggregation subheader is shown in Table E1. This channel aggregation subheader is used to manage the aggregation data sequence and aggregation type during the multi-channel operation. The channel aggregation header with fixed-length size of 3 bytes shall be added to each PDU after the generic MAC header.

Table E1—Aggregation subheader format

Syntax	Size	Notes
Aggregation_Header_Format() {		
Aggregation ID	16 bits	Indicates the sequence management ID of the transmitted data during multi-channel operation. The value of Aggregation ID is from 0 to 8191. The Aggregation ID shall be incremented by one after each transmission and shall be reset to 0 after the maximum value (8191).
Aggregation Type	8 bits	This field specifies the aggregation type of the transmission. 0x00: No aggregation. 0x01: Diversity mode. 0x02: Bulk transmission mode. 0x03-0xFF: Reserved.
}		

7.7 Management messages

Insert new messages in Table 19.

Table 19—Management messages

Type	Message	Descriptions	Reference	Class of connection
41	LCU-REQ	Local Cell Update Request	7.7.25.1	Primary Management
42	LCU-RSP	Local Cell Update Response	7.7.25.2	Primary Management
43	Container	Container	7.7.26	Primary Management
44	Container ACK	Container acknowledgment	7.7.26.1	Primary Management
45	DTT-REQ	Downstream Transit Test Request	7.7.27.1	Primary Management
46	DTT-RSP	Downstream Transit Test Response	7.7.27.2	Primary Management
47	DTT-RPT	Downstream Transit Test Report	7.7.27.3	Primary Management
48	DTT-CFM	Downstream Transit Test Confirmation	7.7.27.4	Primary Management
49	Relay-SCHE	Relay	7.7.28	Primary Management
50	CAM-AIF	Add new operating channel	7.7.29.1	Primary Management
51	CAM-STP	Stop operating channel	7.7.29.2	Primary Management
52	CAM-STP-ACK	Stop operating channel acknowledgment	7.7.29.3	Primary Management

Table 19—Management messages

Type	Message	Descriptions	Reference	Class of connection
53	CAM-SWH	Switch operating channel	7.7.29.4	Primary Management
54	CAM-SWH-ACK	Switch operating channel acknowledgment	7.7.29.5	Primary Management
55	GRA-CFG	Group Resource Allocation Configuration	7.7.30.1	Primary Management
56	GRA-UPD	Group Resource Allocation Update	7.7.30.2	Primary Management

7.7.1 Downstream Channel Descriptor (DCD)

Change the paragraph as follows:

The format of a DCD message is shown in Table 20. This message shall be transmitted by the BS/MR-BS or the distributed scheduling R-CPE at a periodic interval (Table 273) to define the characteristics of a downstream physical channel.

Change Table 20 as follows:

Table 20 — DCD message format

Syntax	Size	Note
DCD_Message_Format() {		
Management Message Type = 0	8 bits	
Configuration Change Count	8 bits	Incremented by one (modulo 256) by the BS or the distributed scheduling R-CPE whenever any of the values of this channel descriptor change. If the value of this count in a subsequent DCD remains the same, the CPE can quickly decide that the remaining fields have not changed and may be able to disregard the remainder of the message. This value is also referenced from the DS-MAP messages (see Table 25).
DCD Channel Information Elements (IEs)	Variable in integer number of bytes	Table 21
Begin PHY Specific Section {		
Number of downstream burst profiles: n	~~6~~7 bits	Number of burst profiles described in the current DCD message. Its maximum size corresponds to the maximum number of DIUC burst profiles contained in Table 27.

Table 20 — DCD message format

Syntax	Size	Note
Reserved	~~2~~1 bits	All bits shall be set to zero.
for (*i* = 1; *i*=<n; *i*++) {		"n" is defined as the "Number of downstream burst profiles" to be described in the current DCD message.
Downstream_Burst_Profile	Variable	PHY specific (Table 23).
}		

7.7.1.1 DCD Channel information elements

Change Table 21 as follows:

Table 21 — DCD channel information elements

Name	Element ID (1 byte)	Length (bit)	Description
Downstream_Burst_Pro-file	1	Variable	Value reserved for the burst profile (see Table 23)
$EIRP_{BS}$	2	8	Signed in units of dBm in 0.5 dB steps with a range from –64 dBm (encoded 0x00) to +63.5 dBm (encoded 0xFF). Values outside this range shall be assigned the closest extreme.
TTG	3	8	0x00–0xFF: range of TTG in 2.75 µs increments. Default set to 0x4D to allow for 210 µs for 30 km propagation.
$RSS_{IR\_BS\_nom}$	4	8	Initial ranging nominal signal strength per subcarrier to be received at the BS by a 0 dBi antenna gain, i.e., corrected for the gain of the BS receive antenna in the direction of the CPE and for 0 coupling and cable loss (see 7.14.2.8.1). Signed in units of dBm in 0.5 dB steps ranging from –104 dBm (encoded 0x00) to +23.5 dBm (encoded 0xFF). Values outside this range shall be assigned the closest extreme.
Channel Action	5	3	Action to be taken by all CPEs in a cell. 000: None 001: Switch 010–111: *Reserved*

Table 21 — DCD channel information elements

Name	Element ID (1 byte)	Length (bit)	Description
Action Mode	6	1	This is valid only for channel switch (Action = 001). Indicates a restriction on transmission until the specified Channel Action is performed. The BS shall set the Action Mode field to either 0 or 1 on transmission. A value of 1 means that the CPE to which the frame containing this element is addressed shall transmit no further frames until the scheduled Channel Action is performed. An Action Mode set to 0 does not impose any requirement on the receiving CPE.
Action Superframe Number	7	8	The superframe number (modulo 256) at which Channel Action shall be performed.
Action Frame Number	8	48	Integer value greater than or equal to zero that indicates the starting frame number, within the Action Superframe Number, at which the Channel Action shall be performed by all CPEs.
Number of Backup channels	9	4	Number of backup channels in the backup and candidate channel list IE (see Table 22).
Backup and Candidate channel list.	10	Variable	See Table 22 for specification.
MAC version	11	8	IEEE 802.22 MAC version to which the message originator conforms. 0x01: IEEE Std 802.22 0x02: IEEE Std. 802.22b 0x03–0xFF: *Reserved*
Relay-TTG	12	8	0x00–0xFF: range of Relay TTG in 2.75 µs increments. Default set to 0x4D to allow for 210 µs for 30 km propagation.
$EIRP_{R\text{-}CPE}$	13	8	Signed in units of dBm in 0.5 dB steps with a range from –64 dBm (encoded 0x00) to +63.5 dBm (encoded 0xFF). Values outside this range shall be assigned the closest extreme.
$RSS_{IR\_R\text{-}CPE\_nom}$	14	8	Initial ranging nominal signal strength per subcarrier to be received at the BS by a 0 dBi antenna gain, i.e., corrected for the gain of the BS receive antenna in the direction of the CPE and for 0 coupling and cable loss (see 7.14.2.8.1). Signed in units of dBm in 0.5 dB steps ranging from –104 dBm (encoded 0x00) to +23.5 dBm (encoded 0xFF). Values outside this range shall be assigned the closest extreme.

Change Table 22 as follows:

Table 22—Backup and Candidate channel list

Syntax	Size	Note
Backup_and_candidate_channel_list_IE_Format() {		
Element ID = 10	8 bits	
Length	8 bits	
Number of Channels in the list	8 bits	
For (i=0; i < Number of Channels in the list; i++) {		List of backup channels in order of priority to be used by CPEs in case of loss of communication with the BS due to incumbents. This list may also include candidate channels, in which case they will follow the backup channels in the list, and will also be included in order of priority. The number of backup channels in the list is indicated in DCD Element ID 9 (See Table 21). The list shall be a disjoint set with the current operating channel.
Channel Number [i]	8 bits	
Group Flag	1 bit	Flag to indicate whether the backup and ~~or~~ candidate channels are ~~is~~ used globally within a cell or locally within a group 0: Used globally within a cell 1: Used locally within a group
If(Group Flag=1){		
GID [i]	12 bits	Group ID at which the backup and candidate channels are used locally within a group
}		
}		
}		

7.7.1.2 Downstream Burst Profile

Change the size from 6 bits to 7 bits for DIUC and from 2 bits to 1 bit for reserved in Table 23 :

7.7.2 Downstream MAP (DS-MAP)

Change Table 25 as follows:

Table 25 — DS-MAP message format

Syntax	Size	Note
DS-MAP_Message_Format() {		
Management Message Type = 1	8 bits	
DCD Count	8 bits	Matches the value of the configuration change count of the DCD, which describes the downstream burst profiles that apply to this map.
If (transmitted by BS or MR-BS) {		
Begin PHY Specific Section {		
Number of IEs: n	12 bits	Number of IEs in the downstream map
for (*i* = 1; *i*=< n; i++) {		PHY specific (7.7.2.1)
DS-MAP_IE()	Variable	
}		
}		
}		
else if (transmitted by distributed scheduling R-CPE) {		
Begin PHY Specific Section {		
Number of DRZDS-MAP IEs: n	12 bits	Number of individual resource allocation (IRA) IEs in the downstream map
for (*i* = 1; *i* ≤ n; i++) {		
DRZDS-MAP_IE()	Variable	PHY specific (7.7.2.4)
}		
Number of DRZDS-MAP-GRA-IEs: m	12 bits	Number of group resource allocation (GRA) IEs in the downstream map
for (i = 1; i ≤ m; i++) {		
DRZDS-MAP-GRA-IE()	Variable	PHY specific (Table 7.7.2.5)
}		
}		
If(!byte_boundary)		

Table 25 — DS-MAP message format

Syntax	Size	Note
Padding bits	0-7 bits	
}		

7.7.2.1 DS-MAP IE

Change the size from 9 bits to 13 bits for SID, and from 6 bits to 7 bits for DIUC in Table 26 :

7.7.2.1.1 DIUC allocations

Insert the values from 63 to 126 in Table 27:

Table 27—DIUC values

DIUC	Usage		
63	Convolutional Code	FEC rate = 1/2	256-QAM
64	Convolutional Code	FEC rate = 2/3	256-QAM
65	Convolutional Code	FEC rate = 3/4	256-QAM
66	Convolutional Code	FEC rate = 5/6	256-QAM
67	Convolutional Code	FEC rate = 7/8	256-QAM
68	Convolutional Code	FEC rate = 10/11 for 2*2 D symbol	4D-48TCM
69	Convolutional Code	FEC rate = 14/15 for 2*2 D symbol	4D-192TCM
70	CTC	FEC rate = 1/2	256-QAM
71	CTC	FEC rate = 2/3	256-QAM
72	CTC	FEC rate = 3/4	256-QAM
73	CTC	FEC rate = 5/6	256-QAM
74	CTC	FEC rate = 7/8	256-QAM
75	CTC	FEC rate = 10/11 for 2*2 D symbol	4D-48TCM
76	CTC	FEC rate = 14/15 for 2*2 D symbol	4D-192TCM

Table 27—DIUC values

DIUC	Usage		
77	LDPC	FEC rate = 1/2	256-QAM
78	LDPC	FEC rate = 2/3	256-QAM
79	LDPC	FEC rate = 3/4	256-QAM
80	LDPC	FEC rate = 5/6	256-QAM
81	LDPC	FEC rate = 7/8	256-QAM
82	LDPC	FEC rate = 10/11 for 2*2 D symbol	4D-48TCM
83	LDPC	FEC rate = 14/15 for 2*2 D symbol	4D-192TCM
84	SBTC	FEC rate = 1/2	256-QAM
85	SBTC	FEC rate = 2/3	256-QAM
86	SBTC	FEC rate = 3/4	256-QAM
87	SBTC	FEC rate = 5/6	256-QAM
88	SBTC	FEC rate = 7/8	256-QAM
89	SBTC	FEC rate = 10/11 for 2*2 D symbol	4D-48TCM
90		FEC rate = 14/15 for 2*2 D symbol	4D-192TCM
91 - 126	reserved		

7.7.2.1.2 DS-MAP Extended DIUC IE

Change Table 28 as follows:

Table 28 — DS-MAP Extended IE general format

Syntax	Size	Note
DS_Extended_IE() {		

Table 28 — DS-MAP Extended IE general format

Syntax	Size	Note
Type	8 bits	
Extended DIUC	~~6~~7 bits	
Length	8 bits	Length of this IE in bits.
Unspecified Data	Variable	
}		

Add Table 28a as follows:

Table 28a — Extended DIUC code assignment

Extended DIUC	Usage
0	DS-MAP Dummy Extended IE
1	DS Multi-Zone Configuration IE
2	
3	
4	

7.7.2.1.2.1 DS-MAP Dummy Extended IE

Change the size from 6 bits to 7 bits for Extended DIUC in Table 29 :

7.7.2.1.2.2 DS Multi-Zone Configuration IE

A CPE shall be able to decode the DS Multi-Zone Configuration IE shown in Table F1. An MR-BS shall transmit this IE for multi-hop relay operations.

Table F1—DS Multi-Zone Configuration IE format

Syntax	Size	Notes
DS Multi-Zone Configuration_IE() {		
Type	8 bits	
Length	12 bits	Length of this IE in bits.
Multi-Zone Configuration{		
Number of zones	8 bits	Number of zones including access and relay zones. Number of zones (0) is not available of DS. Number of zone (1) shall be access zone.
For(i=1; i =< Number of zones; i++){		
Zone Index	8 bits	Increase the index from 0 to Number of Zones-1
Zone Mode	2 bits	0: access zone 1: centralized relay zone 2: distributed relay zone
Used Segment Bitmap	4 bits	Bit 1: Segment 0 Bit 2: Segment 1 Bit 3: Segment 2 Bit 4: Reserved Segmentation is only used in distributed relay zone
}		
}		
for(Zone index=0; Zone index < Number of zones; Zone index++){		
OFDMA symbol offset	7 bits	The zone starts at the OFDMA symbol offset, counted after the preamble of the frame
Zone duration	5 bits	The zone ends after the zone duration starting from the OFDMA symbol offset. The unit of duration is an OFDMA symbol
If (Zone mode == 0){		Access Zone Mode
Number of AZDS-MAP IEs: n	12 bits	Number of AZDS-MAP IEs in the downstream map
for (*j* = 1; *j* =< n; *j*++) {		
AZDS-MAP_IE()	Variable	PHY specific (7.7.2.2)
}		
}		

Table F1—DS Multi-Zone Configuration IE format

Syntax	Size	Notes
else if (Zone mode == 1){		Centralized Relay Zone (CRZ) mode
Number of CRZDS-MAP IEs: n	12 bits	Number of CRZDS-MAP IEs in the downstream map
for (*j* = 1; *j* =<n; *j*++) {		
CRZDS-MAP_IE()	Variable	PHY specific (7.7.2.3)
}		
}		
Else if (Zone mode == 2) {		Distributed Relay Zone (DRZ) mode
SID	13 bits	
}		
}		
}		

7.7.2.2 Access Zone DS-MAP IE (AZDS-MAP IE)

Encodings of Access Zone DS-MAP IE for the downstream from the MR-BS are provided in Table G1.

Table G1—AZDS-MAP IE

Syntax	Size	Notes
AZDS-MAP_IE(){		
Type	8 bits	
DIUC	7 bits	7.7.2.1.1
SID	13 bits	Station ID of CPE or multicast group.
Length	12 bits	Number of OFDM slots linearly allocated to the DS burst specified by this IE.
Boosting	3 bits	111: +9 dB 110: +6 dB 101: +3 dB 100: 0 dB, normal (not boosted) 011: –3 dB 010: –6 dB 001: –9 dB 000: –12 dB

Table G1—AZDS-MAP IE

Syntax	Size	Notes
}		

Table H1—CRZDS-MAP IE

Syntax	Size	Notes
CRZDS-MAP_IE(){		
Type	8 bits	
DIUC	7 bits	7.7.2.1.1
SID	13 bits	Station ID of CPE or multicast group.
CRZ Start Offset	12 bits	Number of OFDMA slots counted after the centralized relay zone mode start
Length	12 bits	Number of OFDM slots linearly allocated to the CRZDS burst specified by this IE.
Boosting	3 bits	111: +9 dB 110: +6 dB 101: +3 dB 100: 0 dB, normal (not boosted) 011: –3 dB 010: –6 dB 001: –9 dB 000: –12 dB
}		

7.7.2.3 Centralized Relay Zone DS-MAP IE (CRZDS-MAP IE)

Encodings of Centralized Relay Zone DS-MAP IE for the relay downstream from the centralized scheduling R-CPE to the S-CPE are provided in Table H1.

7.7.2.4 Distributed Relay Zone DS-MAP IE (DRZDS-MAP IE)

Encodings of Distributed Relay Zone DS-MAP IE for the relay downstream from the distributed scheduling R-CPE to the S-CPE are provided in Table I1.

Table I1—DRZDS-MAP IE

Syntax	Size	Notes
DRZDS-MAP_IE(){		
Type	8 bits	

Table I1—DRZDS-MAP IE

Syntax	Size	Notes
DIUC	7 bits	7.7.2.1.1
SID	13 bits	Station ID of CPE or multicast group.
Length	12 bits	Number of OFDM slots linearly allocated to the DS burst specified by this IE.
Boosting	3 bits	111: +9 dB 110: +6 dB 101: +3 dB 100: 0 dB, normal (not boosted) 011: –3 dB 010: –6 dB 001: –9 dB 000: –12 dB
}		

7.7.2.5 DRZDS-MAP GRA IE

The format of the DRZDS-MAP GRA IE is shown in Table J1.

Table J1—DRZDS-MAP GRA information elements

Syntax	Size	Notes
DRZDS-MAP_GRA_IE() {		
Resource Allocation Bitmap	Variable (1 bits * number of devices in the group)	Indicates whether the resources are allocated to the device in a group. The number of devices in the group is determined by the Device Bitmap Size in GRA Configuration Message. 0: not allocated in the frame 1: allocated in the frame
Resource Starting Index	11 bits	Indicates the starting index of resource in the unit of OFDMA slot. In the DS subframe, the index starts right after the frame preamble from 0. In the US subframe, the index 0 starts from the ranging/BW request/UCS notification contention windows (not including SCW) if it exists.

Table J1—DRZDS-MAP GRA information elements

Syntax	Size	Notes
Resource Size Bitmap	Variable (3 bits * number of devices in the group)	Indicates the resource allocation size for the device in the unit of OFDMA slot. 000: 1 001: 2 010: 4 011: 8 100: 16 101: 32 110: 64 111: 128
Group DIUC Flag	1 bit	Indicates whether the DIUC is fixed within group. 0: not fixed within group 1: fixed within group
Group Boosting Flag	1 bit	Indicates whether the Boosting is fixed within group. 0: not fixed within group 1: fixed within group
If (Group DIUC Flag = 0) {		
Group DIUC Bitmap	Variable (6 bits * number of devices in the group)	Specifies the DIUC of each device in a group
}		
Else{		
DIUC	7 bits	Same DIUC is used by all device in a group
}		
If (Group Boosting Flag = 0) {		
Group Boosting Bitmap	Variable (3 bits * number of devices in the group)	Specifies the Boosting of each device in a group
}		
Else{		
Boosting	3 bits	Same Boosting is used by all device in a group
}		
}		

7.7.3 Upstream Channel Descriptor (UCD

The format of a UCD message is shown in Table 30. This message shall be transmitted by the BS/MR-BS or the distributed scheduling R-CPE at a periodic interval (Table 272) to define the characteristics of an upstream physical channel.

Change Table 30 as follows:

Table 30—UCD message format

Syntax	Size	Notes
UCD_Message_Format() {		
Management Message Type = 2	8 bits	
Configuration Change Count	8 bits	Incremented by one (modulo 256) by the BS whenever any of the values of this channel descriptor change. If the value of this count in a subsequent UCD remains the same, the CPE can quickly decide that the remaining fields have not changed and may be able to disregard the remainder of the message. This value is also referenced from the US-MAP messages (see Table 34).
BW Request Backoff Start	4 bits	Initial backoff window size in units of BW Request opportunity or DRZ BW Request (see Table 31) used by CPEs to contend to send BW requests to the BS or to send DRZ BW request to the distributed scheduling R-CPE, expressed as a power of 2. Values of *n* range 0–15. Refer in the note to 6.16 on Contention Resolution.Include a subsection that will describe the size and the content of the BW Request US burst and refer to it in the note.
BW Request Backoff End	4 bits	Final backoff window size in units of BW Request opportunity or DRZ BW Request (see Table 39) to contend to send BW requests to the BS or to send DRZ BW request to the distributed scheduling R-CPE, expressed as a power of 2. Values of *n* range 0–15. All declared opportunities for BW request in subsequent frames
UCS Notification Backoff Start	4 bits	Initial backoff window size in units of UCS notification opportunity or DRZ UCS notification opportunity (see Table 31) used by CPEs to contend to send UCS notifications to the BS or to send DRZ UCS notifications to the distributed scheduling R-CPE. This is expressed as a power of 2. Values of *n* range 0–15.

Table 30—UCD message format

Syntax	Size	Notes
UCS Notification Backoff End	4 bits	Final backoff window size in units of UCS notification opportunity or DRZ UCS notification opportunity (see Table 31) used by CPEs to contend to send UCS notifications to the BS or to send DRZ UCS notifications to the distributed scheduling R-CPE. This is expressed as a power of 2. Values of *n* range 0–15. All declared opportunities for UCS Notifications in subsequent frames are concatenated in this potentially large number.
Information elements (IEs) for the overall channel	Variable	See 7.7.3.1.
Begin PHY Specific Section {		
Number of upstream burst profiles:*n*	~~6~~7 bits	Number of upstream burst profiles described in the current UCD message. Its maximum size corresponds to the maximum number of UIUC burst profiles contained in Table 36.
for (*i* = 1; *i* =< n; *i*++) {		n = number of upstream burst profiles
Upstream_Burst_Profile	Variable	PHY specific (Table 32)
}		
}		
}		

7.7.3.1 UCD Channel IEs

Change Table 31 as follows:

Table 31—UCD Channel IE

Name	Element ID	Length (bytes)	Description
Upstream_Burst_Profile	1	Variable	Value reserved for the burst profile (see Table 32)
Contention-based reservation timeout	2	1	Number of US-MAPs to receive before contention-based reservation is attempted again for the same connection

Table 31—UCD Channel IE

Name	Element ID	Length (bytes)	Description
Bandwidth request opportunity size	3	1	Size (in OFDM slots) of PHY bursts, mapped horizontally in one subchannel at a time as in the case of normal upstream data, that a CPE may use to format and transmit a bandwidth request message in a contention request opportunity. The value includes all PHY overhead as well as allowance for the BW Request MAC subheader that the message will hold (see Table 5).
UCS Notification request opportunity size	4	1	Size (in OFDM slots) of PHY bursts, mapped horizontally in one subchannel at a time as in the case of normal upstream data, that a CPE may use to transmit a UCS notification. The value includes all PHY overhead for the GMH containing the UCS flag (see Table 3).
CRZ Bandwidth request opportunity size	5	1	Size (in OFDM slots) of PHY bursts, mapped horizontally in one subchannel at a time as in the case of normal upstream data, that a CPE may use to format and transmit a bandwidth request message in a contention request opportunity. The value includes all PHY overhead as well as allowance for the BW Request MAC subheader that the message will hold (see Table 5).
CRZ UCS Notification request opportunity size	6	1	Size (in OFDM slots) of PHY bursts, mapped horizontally in one subchannel at a time as in the case of normal upstream data, that a CPE may use to transmit a UCS notification. The value includes all PHY overhead for the GMH containing the UCS flag (see Table 3).
DRZ Bandwidth request opportunity size	7	1	Size (in OFDM slots) of PHY bursts, mapped horizontally in one subchannel at a time as in the case of normal upstream data, that a CPE may use to format and transmit a bandwidth request message in a contention request opportunity. The value includes all PHY overhead as well as allowance for the BW Request MAC subheader that the message will hold (see Table 5).
DRZ UCS Notification request opportunity size	8	1	Size (in OFDM slots) of PHY bursts, mapped horizontally in one subchannel at a time as in the case of normal upstream data, that a CPE may use to transmit a UCS notification. The value includes all PHY overhead for the GMH containing the UCS flag (see Table 3).
Initial ranging codes	150	1	Number of initial ranging CDMA codes. Possible values are 0–255.
Periodic ranging codes	151	1	Number of periodic ranging CDM codes. Possible values are 0–255.
Bandwidth request codes	152	1	Number of bandwidth request CDMA codes. Possible values are 0–255.

Table 31—UCD Channel IE

Name	Element ID	Length (bytes)	Description
UCS notification codes	153	1	Number of UCS notification CDMA codes. Possible values are 0–255.
Start of CDMA codes group	154	1	Indicates the starting number, S, of the group of codes used for this upstream. All the ranging codes used on this upstream will be between S and (S+N+M+L+I) mod 56). Where: N is the number of initial-ranging codes M is the number of periodic-ranging codes L is the number of bandwidth-request codes I is the number of UCS notification codes The range of values is $0 \le S \le 255$.
CRZ initial ranging codes	155	1	Number of centralized relay zone (CRZ) initial ranging CDMA codes. Possible values are 0–255.
CRZ periodic ranging codes	156	1	Number of centralized relay zone (CRZ) periodic ranging CDMA codes. Possible values are 0–255.
DRZ initial ranging codes	157	1	Number of distributed relay zone (DRZ) initial ranging CDMA codes. Possible values are 0–255.
DRZ periodic ranging codes	158	1	Number of distributed relay zone (DRZ) periodic ranging CDMA codes. Possible values are 0–255.
CRZ UCS notification codes	159	1	Number of centralized relay zone (DRZ) UCS notification CDMA codes. Possible values are 0–255.
DRZ UCS notification codes	160	1	Number of distributed relay zone (DRZ) UCS notification CDMA codes. Possible values are 0–255.

7.7.3.2 Upstream burst profile

Change the size from 6 bits to 7 bits for UIUC and from 2 bits to 1 bit reserved in Table 32

7.7.4 Upstream MAP (US-MAP)

Change Table 34 as follows:

Table 34—US-MAP message format

Syntax	Size	Notes
US-MAP_Message_Format() {		
Management Message Type = 3		
UCD Count		Matches the value of the Configuration Change Count of the UCD, which describes the upstream burst profiles that apply to this map.

Table 34—US-MAP message format

Syntax	Size	Notes
Allocation Start Time		Effective start time (in OFDM symbols from the start of the frame including all preambles) of the upstream allocation defined by the US-MAP.
If (transmitted by BS or MR-BS) {		
Begin PHY Specific Section {		
Number of IEs: n		Number of IEs in the upstream map
for (*i* = 1; *i* n; *i*++) {		
US-MAP_IE()		PHY specific (7.7.4.1) Define upstream bandwidth allocations. Each US-MAP message shall contain at least one IE that marks the end of the last allocated burst. (UIUC=63 as defined in Table 36).
}		
}		
} else if (transmitted by distributed scheduling R-CPE) {		
Begin PHY Specific Section {		
Number of DRZUS-MAP IEs: n	12 bits	Number of individual resource allocation (IRA) in the upstream map
for (*i* = 1; *i* ≤ n; *i*++) {		
DRZUS-MAP_IE()	Variable	PHY specific (Table 7.7.4.4)
}		
Number of DRZUS-MAP-GRA-IEs: m	12 bits	Number of group resource allocation (GRA) IEs in the upstream map
for (i = 1; i ≤ m; i++) {		
DRZUS-MAP-GRA-IE()	Variable	PHY specific (Table 7.7.4.5) Define upstream bandwidth allocations. Each US-MAP message shall contain at least one IE that marks the end of the last allocated burst. (UIUC=63 as defined in Table 36).
}		
}		
}		
If(!byte_boundary)		

Table 34—US-MAP message format

Syntax	Size	Notes
Padding bits		
}		

7.7.4.1 US-MAP IE

Change the size from 6 bits to 7 bits for UIUC in Table 35

7.7.4.1.1 UIUC allocations

Insert the values from 63 to 126 in Table 36:

Table 36—UIUC values

DIUC	Usage		
63	Convolutional Code	FEC rate = 1/2	256-QAM
64	Convolutional Code	FEC rate = 2/3	256-QAM
65	Convolutional Code	FEC rate = 3/4	256-QAM
66	Convolutional Code	FEC rate = 5/6	256-QAM
67	Convolutional Code	FEC rate = 7/8	256-QAM
68	Convolutional Code	FEC rate = 10/11 for 2*2 D symbol	4D-48TCM
69	Convolutional Code	FEC rate = 14/15 for 2*2 D symbol	4D-192TCM
70	CTC	FEC rate = 1/2	256-QAM
71	CTC	FEC rate = 2/3	256-QAM
72	CTC	FEC rate = 3/4	256-QAM
73	CTC	FEC rate = 5/6	256-QAM
74	CTC	FEC rate = 7/8	256-QAM
75	CTC	FEC rate = 10/11 for 2*2 D symbol	4D-48TCM
76	CTC	FEC rate = 14/15 for 2*2 D symbol	4D-192TCM

Table 36—UIUC values

DIUC	Usage		
77	LDPC	FEC rate = 1/2	256-QAM
78	LDPC	FEC rate = 2/3	256-QAM
79	LDPC	FEC rate = 3/4	256-QAM
80	LDPC	FEC rate = 5/6	256-QAM
81	LDPC	FEC rate = 7/8	256-QAM
82	LDPC	FEC rate = 10/11 for 2*2 D symbol	4D-48TCM
83	LDPC	FEC rate = 14/15 for 2*2 D symbol	4D-192TCM
84	SBTC	FEC rate = 1/2	256-QAM
85	SBTC	FEC rate = 2/3	256-QAM
86	SBTC	FEC rate = 3/4	256-QAM
87	SBTC	FEC rate = 5/6	256-QAM
88	SBTC	FEC rate = 7/8	256-QAM
89	SBTC	FEC rate = 10/11 for 2*2 D symbol	4D-48TCM
90		FEC rate = 14/15 for 2*2 D symbol	4D-192TCM
91 - 126	reserved		

7.7.4.1.2 CDMA Allocation IE

Change the size from 6 bits to 7 bits for UIUC in Table 37:

7.7.4.1.3 US-MAP EIRP Control IE

Change the size from 6 bits to 7 bits for UIUC in Table 38:

7.7.4.1.4 US-MAP Extended UIUC IE

Change Table 39 as follows:

Table 39 — US-MAP extended IE general format

Syntax	Size	Note
US_Extended_IE() {		
Type	8 bits	
Extended UIUC	~~6~~7 bits	
Length	8 bits	Length of this IE in bits.
Unspecified Data	Variable	
}		

Add Table 39a as follows:

Table 39a — Extended UIUC code assignment

Extended UIUC	Usage
0	US-MAP Dummy Extended IE
1	US Multi-Zone Configuration IE
2	
3	
4	

7.7.4.1.4.1 US-MAP Dummy Extended IE

7.7.4.1.4.2 US Multi-Zone Configuration IE

A CPE shall be able to decode the US Multi-Zone Configuration IE shown in Table K1. An MR-BS shall transmit this IE for multi-hop relay operations.

Table K1—US Multi-Zone Configuration IE format

Syntax	Size	Notes
US Multi-Zone Configuration_IE() {		
Type	8 bits	
Length	12 bits	Length of this IE in bits.
Multi-Zone Configuration{		
Number of zones	8 bits	Number of zones including access and relay zones. Number of zones (0) is not available of DS. Number of zone (1) shall be access zone.
For(i=1; i =< Number of zones; i++){		
Zone Index	8 bits	Increase the index from 0 to Number of Zones-1
Zone Mode	2 bits	0: access zone 1: centralized relay zone 2: distributed relay zone
Used Segment Bitmap	4 bits	Bit 1: Segment 0 Bit 2: Segment 1 Bit 3: Segment 2 Bit 4: Reserved Segmentation is only used in distributed relay zone
}		
}		
for(Zone index=0; Zone index < Number of zones; Zone index++){		
OFDMA symbol offset	7 bits	The zone starts at the OFDMA symbol offset, counted after the preamble of the frame
Zone duration	5 bits	The zone ends after the zone duration starting from the OFDMA symbol offset. The unit of duration is an OFDMA symbol
If (Zone mode == 0){		Access Zone Mode
Number of AZUS-MAP IEs: n	12 bits	Number of AZUS-MAP IEs in the downstream map
for (*j* = 1; *j* =< n; *j*++) {		
AZUS-MAP_IE()	Variable	PHY specific (7.7.4.2)
}		
}		

Table K1—US Multi-Zone Configuration IE format

Syntax	Size	Notes
else if (Zone mode == 1){		Centralized Relay Zone (CRZ) mode
Number of CRZUS-MAP IEs: n	12 bits	Number of CRZUS-MAP IEs in the downstream map
for (*j* = 1; *j* =<n; *j*++) {		
CRZUS-MAP_IE()	Variable	PHY specific (7.7.4.3)
}		
}		
Else if (Zone mode == 2) {		Distributed Relay Zone (DRZ) mode
SID	13 bits	
}		
}		
}		

7.7.4.2 Access Zone US-MAP IE (AZUS-MAP IE)

Encodings of Access Zone DS-MAP IE for the upstream to the MR-BS are provided in Table L1.

Table L1—AZUS-MAP IE

Syntax	Size	Notes
AZUS-MAP_IE() {		
SID	13 bits	Station ID of the CPE.
UIUC	7 bits	7.7.4.1.1 (see Table 36).
If ((UIUC=> 0) && (UIUC=<1)) {		Frame number where the active or passive CBP action is to take place.
CBP Frame Number	4 bits	Active SCW mode (CPE to transmit a CBP burst as requested by the BS).
If(UIUC==0) {		

Table L1—AZUS-MAP IE

Syntax	Size	Notes
Timing advance	16 bits	Signed number in TU corresponding to the advance of the transmission of the CBP burst at the CPE. As the CPE starts to transmit the CBP burst as its fourth symbol before the end of the frame, zero advance corresponds to this signal being received by the BS at the beginning of its fourth symbol before the end of the frame when the CPE is co-located with the BS (see Table 44).
EIRP Density Level	8 bits	EIRP per transmitted subcarrier (see 9.9.4.2). Signed in units of 0.5 dB, ranging from –104 dBm (encoded 0x00) to +23.5 dBm (encoded 0xFF).
}		
If(UIUC==1) {		Passive SCW mode (CPE to receive and demodulate the CBP burst and send content to the BS).
Channel Number	8 bits	Channel number in which the CPE shall listen to the medium for a coexistence beacon.
Synchronization mode	1 bit	= 0 The CPE will capture the CBP burst using its current synchronization (i.e., locked to its BS) for geo-location purposes. = 1 The CPE will re-synchronize on the received CBP burst using the preamble symbol and optionally pilot carriers to decode the payload for self-coexistence purposes.
} else if (UIUC =>2) && (UIUC =<3)) {		
Number of Subchannels	4 bits	Number of subchannels reserved for the BW Request/ UCS Notification opportunistic window.
Number of Symbols	5 bits	Number of symbols reserved for the BW Request/ UCS/Notification opportunistic window.
} else if (UIUC =>4) && (UIUC=<6)) {		
Number of Subchannels	4 bits	Number of subchannels reserved for the CDMA Periodic Ranging/BW Request/UCS notification opportunistic window. Note that in case where UIUC=8 and any UIUC in the range 4 to 6 are allocated to a frame, the largest number of subchannel specified shall prevail. Note also that when the CDMA ranging burst is to be used for terrestrially-based geo-location (see 10.5.2), the number of subchannels shall be at least 6.
Number of symbols	5 bits	Number of symbols CDMA Periodic Ranging/BW Request/UCS notification as specified by the respective UIUC. These shall be placed in the ranging channel following the initial ranging window if scheduled and consecutively (see Figure 157).

Table L1—AZUS-MAP IE

Syntax	Size	Notes
} else if (UIUC == 7) {		
CDMA_ Allocation_IE ()	20 bits	See 7.7.4.1.2.
} else if (UIUC == 8) {		
Number of Subchannels	4 bits	Number of subchannels reserved for the initial ranging burst. Note that in case where UIUC=8 and any UIUC in the range 4 to 6 are allocated to a frame, the largest number of claimed subchannels specified shall prevail.
Number of Symbols	5 bits	Number of symbols reserved for the initial ranging burst.
} else if (UIUC == 9) {		
US-MAP EIRP Control IE	Variable	See 7.7.4.1.3.
} else {		
Burst_Type	1 bit	This value specifies the burst type for the burst specified by this US-MAP IE. 0: Bursts are mapped in the time axis over the full width of the upstream subframe before incrementing in the frequency axis. 1: Bursts are mapped in the time axis over segments of 7 symbols before incrementing in the frequency axis and then re-tracing to the lowest unused subchannel in the next 7 symbol segment. The width of the last segment is to be between 7 and 13 symbols depending on the width of the upstream subframe.
Duration	12 bits	Number of OFDM slots linearly allocated to the US burst specified by this IE. (Up to 60 by 30 slots can be allocated to a US burst.)
MDP	1 bit	Measurement Data Preferred Used by the BS to indicate to the CPE that this upstream allocation is to be preferably used by the CPE for the specific purpose of reporting back any measurement data. The measurement data to be reported is in connection to the specified Transaction ID. In case the CPE does not have anything to report, it can use this allocation for any other data. This is useful, for example, after a quiet period. 0: Measurement data not required (default) 1: Measurement data preferred
MRT	1 bit	Measurement Report Type In case MDP == 1, this field indicates which type of report the BS wants the CPE to send back. 0: Detailed (see 7.7.18.3.1.1 through 7.7.18.3.1.8) 1: Consolidated (see 7.7.18.3.1.9)

Table L1—AZUS-MAP IE

Syntax	Size	Notes
CMRP	1 bit	Channel Management Response Preferred Used by the BS to indicate to the CPE that this upstream allocation is to be used for confirming or not the receipt of the channel management command with the Transaction ID specified. 0: Channel management response not required (default) 1: Channel management response required
}		
}		
}		

7.7.4.3 Centralized Relay Zone US-MAP IE (CRZUS-MAP IE)

Encodings of Centralized Relay Zone US-MAP IE for the relay upstream to the centralized scheduling R-CPE from the S-CPE are provided in Table M1.

Table M1—CRZUS-MAP IE

Syntax	Size	Notes
CRZUS-MAP_IE() {		
SID	13 bits	Station ID of the CPE.
UIUC	7 bits	7.7.4.1.1 (see Table 36).
If ((UIUC=> 0) && (UIUC=<1)) {		Frame number where the active or passive CBP action is to take place.
CBP Frame Number	4 bits	Active SCW mode (CPE to transmit a CBP burst as requested by the BS).
If(UIUC==0) {		
Timing advance	16 bits	Signed number in TU corresponding to the advance of the transmission of the CBP burst at the CPE. As the CPE starts to transmit the CBP burst as its fourth symbol before the end of the frame, zero advance corresponds to this signal being received by the BS at the beginning of its fourth symbol before the end of the frame when the CPE is co-located with the BS (see Table 44).

Table M1—CRZUS-MAP IE

Syntax	Size	Notes
EIRP Density Level	8 bits	EIRP per transmitted subcarrier (see 9.9.4.2). Signed in units of 0.5 dB, ranging from –104 dBm (encoded 0x00) to +23.5 dBm (encoded 0xFF).
}		
If(UIUC==1) {		Passive SCW mode (CPE to receive and demodulate the CBP burst and send content to the BS).
Channel Number	8 bits	Channel number in which the CPE shall listen to the medium for a coexistence beacon.
Synchronization mode	1 bit	= 0 The CPE will capture the CBP burst using its current synchronization (i.e., locked to its BS) for geolocation purposes. = 1 The CPE will re-synchronize on the received CBP burst using the preamble symbol and optionally pilot carriers to decode the payload for self-coexistence purposes.
} else if (UIUC =>2) && (UIUC =<3)) {		
Number of Subchannels	4 bits	Number of subchannels reserved for the Relay BW Request/UCS Notification opportunistic window.
Number of Symbols	5 bits	Number of symbols reserved for the Relay BW Request/UCS/Notification opportunistic window.
} else if (UIUC =>4) && (UIUC=<6)) {		
Number of Subchannels	4 bits	Number of subchannels reserved for the Relay CDMA Periodic Ranging/BW Request/UCS notification opportunistic window. Note that in case where UIUC=8 and any UIUC in the range 4 to 6 are allocated to a frame, the largest number of subchannel specified shall prevail. Note also that when the CDMA ranging burst is to be used for terrestrially-based geolocation (see 10.5.2), the number of subchannels shall be at least 6.
Number of symbols	5 bits	Number of symbols Relay CDMA Periodic Ranging/BW Request/UCS notification as specified by the respective UIUC. These shall be placed in the ranging channel following the initial ranging window if scheduled and consecutively (see Figure 157).
} else if (UIUC == 7) {		
CDMA_Allocation_IE ()	20 bits	See 7.7.4.1.2.
} else if (UIUC == 8) {		

Table M1—CRZUS-MAP IE

Syntax	Size	Notes
Number of Subchannels	4 bits	Number of subchannels reserved for the Relay initial ranging burst. Note that in case where UIUC=8 and any UIUC in the range 4 to 6 are allocated to a frame, the largest number of claimed subchannels specified shall prevail.
Number of Symbols	5 bits	Number of symbols reserved for the Relay initial ranging burst.
} else if (UIUC == 9) {		
US-MAP EIRP Control IE	Variable	See 7.7.4.1.3.
} else {		
Burst_Type	1 bit	This value specifies the burst type for the burst specified by this US-MAP IE. 0: Bursts are mapped in the time axis over the full width of the upstream subframe before incrementing in the frequency axis. 1: Bursts are mapped in the time axis over segments of 7 symbols before incrementing in the frequency axis and then re-tracing to the lowest unused subchannel in the next 7 symbol segment. The width of the last segment is to be between 7 and 13 symbols depending on the width of the upstream subframe.
Duration	12 bits	Number of OFDM slots linearly allocated to the US burst specified by this IE. (Up to 60 by 30 slots can be allocated to a US burst.)
MDP	1 bit	Measurement Data Preferred Used by the BS to indicate to the CPE that this upstream allocation is to be preferably used by the CPE for the specific purpose of reporting back any measurement data. The measurement data to be reported is in connection to the specified Transaction ID. In case the CPE does not have anything to report, it can use this allocation for any other data. This is useful, for example, after a quiet period. 0: Measurement data not required (default) 1: Measurement data preferred
MRT	1 bit	Measurement Report Type In case MDP == 1, this field indicates which type of report the BS wants the CPE to send back. 0: Detailed (see 7.7.18.3.1.1 through 7.7.18.3.1.8) 1: Consolidated (see 7.7.18.3.1.9)

Table M1—CRZUS-MAP IE

Syntax	Size	Notes
CMRP	1 bit	Channel Management Response Preferred Used by the BS to indicate to the CPE that this upstream allocation is to be used for confirming or not the receipt of the channel management command with the Transaction ID specified. 0: Channel management response not required (default) 1: Channel management response required
}		
}		
}		

7.7.4.4 Distributed Relay Zone US-MAP IE (DRZUS-MAP IE)

Encodings of Distributed Relay Zone US-MAP IE for the relay upstream to the distributed scheduling R-CPE from the S-CPE are provided in Table N1.

Table N1—DRZUS-MAP IE

Syntax	Size	Notes
DRZUS-MAP_IE() {		
SID	13 bits	Station ID of the CPE.
UIUC	7 bits	7.7.4.1.1 (see Table 36).
If ((UIUC=> 0) && (UIUC=<1)) {		Frame number where the active or passive CBP action is to take place.
CBP Frame Number	4 bits	Active SCW mode (CPE to transmit a CBP burst as requested by the BS).
If(UIUC==0) {		
Timing advance	16 bits	Signed number in TU corresponding to the advance of the transmission of the CBP burst at the CPE. As the CPE starts to transmit the CBP burst as its fourth symbol before the end of the frame, zero advance corresponds to this signal being received by the BS at the beginning of its fourth symbol before the end of the frame when the CPE is co-located with the BS (see Table 44).

Table N1—DRZUS-MAP IE

Syntax	Size	Notes
EIRP Density Level	8 bits	EIRP per transmitted subcarrier (see 9.9.4.2). Signed in units of 0.5 dB, ranging from –104 dBm (encoded 0x00) to +23.5 dBm (encoded 0xFF).
}		
If(UIUC==1) {		Passive SCW mode (CPE to receive and demodulate the CBP burst and send content to the BS).
Channel Number	8 bits	Channel number in which the CPE shall listen to the medium for a coexistence beacon.
Synchronization mode	1 bit	= 0 The CPE will capture the CBP burst using its current synchronization (i.e., locked to its BS) for geo-location purposes. = 1 The CPE will re-synchronize on the received CBP burst using the preamble symbol and optionally pilot carriers to decode the payload for self-coexistence purposes.
} else if (UIUC =>2) && (UIUC =<3)) {		
Number of Subchannels	4 bits	Number of subchannels reserved for the DRZ BW Request/ UCS Notification opportunistic window.
Number of Symbols	5 bits	Number of symbols reserved for the DRZ BW Request/UCS/ Notification opportunistic window.
} else if (UIUC =>4) && (UIUC=<6)) {		
Number of Subchannels	4 bits	Number of subchannels reserved for the DRZ CDMA Periodic Ranging/BW Request/UCS notification opportunistic window. Note that in case where UIUC=8 and any UIUC in the range 4 to 6 are allocated to a frame, the largest number of subchannel specified shall prevail. Note also that when the CDMA ranging burst is to be used for terrestrially-based geo-location (see 10.5.2), the number of subchannels shall be at least 6.
Number of symbols	5 bits	Number of symbols DRZ CDMA Periodic Ranging/BW Request/UCS notification as specified by the respective UIUC. These shall be placed in the ranging channel following the initial ranging window if scheduled and consecutively (see Figure 157).
} else if (UIUC == 7) {		
CDMA_ Allocation_IE ()	20 bits	See 7.7.4.1.2.
} else if (UIUC == 8) {		
Number of Subchannels	4 bits	Number of subchannels reserved for the DRZ initial ranging burst. Note that in case where UIUC=8 and any UIUC in the range 4 to 6 are allocated to a frame, the largest number of claimed subchannels specified shall prevail.
Number of Symbols	5 bits	Number of symbols reserved for the DRZ initial ranging burst.

Table N1—DRZUS-MAP IE

Syntax	Size	Notes
} else if (UIUC == 9) {		
US-MAP EIRP Control IE	Variable	See 7.7.4.1.3.
} else {		
Burst_Type	1 bit	This value specifies the burst type for the burst specified by this US-MAP IE. 0: Bursts are mapped in the time axis over the full width of the upstream subframe before incrementing in the frequency axis. 1: Bursts are mapped in the time axis over segments of 7 symbols before incrementing in the frequency axis and then re-tracing to the lowest unused subchannel in the next 7 symbol segment. The width of the last segment is to be between 7 and 13 symbols depending on the width of the upstream subframe.
Duration	12 bits	Number of OFDM slots linearly allocated to the US burst specified by this IE. (Up to 60 by 30 slots can be allocated to a US burst.)
MDP	1 bit	Measurement Data Preferred Used by the distributed scheduling R-CPE to indicate to the CPE that this upstream allocation is to be preferably used by the CPE for the specific purpose of reporting back any measurement data. The measurement data to be reported is in connection to the specified Transaction ID. In case the CPE does not have anything to report, it can use this allocation for any other data. This is useful, for example, after a quiet period. 0: Measurement data not required (default)
MRT	1 bit	Measurement Report Type In case MDP == 1, this field indicates which type of report the BS wants the CPE to send back. 0: Detailed (see 7.7.18.3.1.1 through 7.7.18.3.1.8) 1: Consolidated (see 7.7.18.3.1.9)
CMRP	1 bit	Channel Management Response Preferred Used by the distributed scheduling R-CPE to indicate to the CPE that this upstream allocation is to be used for confirming or not the receipt of the channel management command with the Transaction ID specified. 0: Channel management response not required (default) 1: Channel management response required
}		
}		
}		

7.7.4.5 DRZUS-MAP GRA IE

The format of the DRZUS-MAP GRA IE is shown in Table O1

Table O1—DRZUS-MAP GRA information element

Syntax	Size	Notes
DRZUS-MAP_GRA_IE() {		
Resource Allocation Bitmap	Variable (1 bits * number of devices in the group)	Indicates whether the resources are allocated to the device in a group. The number of devices in the group is determined by the Device Bitmap Size in GRA Configuration Message. 0: not allocated in the frame 1: allocated in the frame
Resource Starting Index	11 bits	Indicates the starting index of resource in the unit of OFDMA slot. In the DS subframe, the index starts right after the frame preamble from 0. In the US subframe, the index 0 starts from the ranging/BW request/UCS notification contention windows (not including SCW) if it exists.
Resource Size Bitmap	Variable (3 bits * number of devices in the group)	Indicates the resource allocation size for the device in the unit of OFDMA slot. 000: 1 001: 2 010: 4 011: 8 100: 16 101: 32 110: 64 111: 128
Group UIUC Flag	1 bit	Indicates whether the UIUC is fixed within group. 0: not fixed within group 1: fixed within group
Group Burst_Type Flag	1 bit	Indicates whether the Burst_Type is fixed within group. 0: not fixed within group 1: fixed within group
Group MDP Flag	1 bit	Indicates whether the MDP is fixed within group. 0: not fixed within group 1: fixed within group
Group MRT Flag	1 bit	Indicates whether the MRT is fixed within group. 0: not fixed within group 1: fixed within group
Group CMRP Flag	1 bit	Indicates whether the CMRP is fixed within group. 0: not fixed within group 1: fixed within group

Table O1—DRZUS-MAP GRA information element

Syntax	Size	Notes
If (Group UIUC Flag = 0) {		
Group UIUC Bitmap	Variable (6 bits * number of devices in the group)	Specifies the UIUC of each device in a group
}		
Else {		
UIUC	7 bits	Same UIUC is used by all device in a group
}		
If (Group Burst_Type Flag = 0) {		
Group Burst_Type Bitmap	Variable (1 bits * number of devices in the group)	Specifies the Burst_Type of each device in a group
}		
Else{		
Burst_Type	1 bit	Same Burst_Type is used by all device in a group
}		
If (Group MDP Flag = 0) {		
Group MDP Bitmap	Variable (1 bits * number of devices in the group)	Specifies the MDP of each device in a group
}		
Else{		
MDP	1 bit	Same MDP is used by all device in a group
}		
If(Group MRT Flag = 0) {		
Group MRT Bitmap	Variable (1 bits * number of devices in the group)	Specifies the MRT of each device in a group

Table O1—DRZUS-MAP GRA information element

Syntax	Size	Notes
}		
Else{		
MRT	1 bit	Same MRT is used by all device in a group
}		
If(Group CMRP Flag = 0) {		
Group CMRP Bitmap	Variable (1 bits * number of devices in the group)	Specifies the CMRP of each device in a group
}		
Else{		
CMRP	1 bit	Same CMRP is used by all device in a group
}		
}		

7.7.7 REG-REQ/RSP

7.7.7.3 REG-REQ/RSP information elements

7.7.7.3.6 Local SID Group

The format of a Local SID IE is shown in Table P1. This IE shall be transmitted by the MR-BS to the distributed scheduling R-CPE at registration.Instead of the MR-BS, the distributed scheduling R-CPE allocates a Local SID to the S-CPE at initialization.

Table P1—Local SID Group Information element

Syntax	Size	Notes	Scope
Local SID Group_IE(){			REG-RSP
Element ID	8 bits		
Number of SIDs	8 bits	Total number of SIDs assigned for a distributed scheduling R-CPE	
SIDs	13 bits	Start SID; A group of SIDs will be allocated from SID.	

7.7.7.3.6.12 Permanent Station ID

Change the value of Table 61 as follows:

Table 61—Permanent Station ID information element

Element ID	Length (bytes)	Value	Scope
15	2	Permanent ID (Bit ~~0000 000b bbbb bbbb~~ 000b bbbb bbbb bbbb)	REG-REQ/RSP

7.7.7.3.4.13 CPE Operational Capability

Change Table 62 as follows:

Table 62—CPE Operational Capability information element

Element ID	Length (bytes)	Value	Scope
16	1	0x00- Fixed (no relay) 0x01: Portable (no relay) 0x02: Centralized scheduling R-CPE (fixed only) 0x03: Distributed scheduling R-CPE (fixed) 0x04: Distributed scheduling R-CPE (portable Mode II) 0x04–0xFF: *Reserved*	REG-REQ/RSP

7.7.8.9 Service Flow encodings

7.7.8.9.19 Per-RS QoS

The format of a Per-RS QoS IE is shown in Table Q1.

Table Q1—Per-RS QoS information elements

Name	Element ID	Length	Value	Scope
Per-RS QoS		Variable	Compound	DSA-REQ/RSP DSC-REQ/RSP

Per-RS QoS value is shown in Table R1 as following.

Table R1—Per-RS QoS value

Name	Type (1 byte)	Length (1 byte)	Value
RS_Basic_CID		2	RS Basic CID
Maximum_Latency_for the RS		4	Milliseconds

The value of Maximum Latency for the R-CPE specifies the maximum interval between the reception of an MAC PDU at the R-CPE's Air Interface that is receiving the MAC PDU and the Air Interface that is forwarding the MAC PDU.

7.7.11 CPE Basic Capability Request/Response (CBC-REQ/RSP)

7.7.11.1 CBC-REQ

7.7.11.3.2.2.3 Centralized Scheduling R-CPE Demodulator

The format of a Centralized Scheduling R-CPE Demodulator IE is shown inTable S1. This field indicates the different demodulator options supported by a centralized scheduling R-CPE for the downstream reception.

Table S1—Centralized Scheduling R-CPE Demodulator

Element ID	Length (bytes)	Value	Scope
xx	1	For a particular mode being represented, see the corresponding index in Table 27 (DIUC values)	CBC-RSP

7.7.11.3.2.2.4 Centralized Scheduling R-CPE Modulator

The format of a Centralized Scheduling R-CPE Demodulator IE is shown in Table T1. This field indicates the different modulator options supported by a centralized scheduling R-CPE for upstream transmission.

Table T1—Centralized Scheduling R-CPE Modulator

Element ID	Length (bytes)	Value	Scope
xx	1	For a particular mode being represented, see the corresponding index in Table 36 (UIUC values)	CBC-RSP

7.7.11.3.4 Relay CPE Mode

The format of a Relay CPE Mode IE is shown in Table U1. This IE defines a relay operation mode for the CPEs.

Table U1—Relay CPE Mode information element

Element ID	Length (bytes)	Value	Scope
xx	1	0: No support Relay 1: Centralized Scheduling R-CPE Support 2: Distributed Scheduling R-CPE Support	CBC-REQ

7.7.11.3.5 Multi-channel operation supported

This information element indicates the capability of the CPE whether the multi-channel operation is supported or not supported

Table V1—Multi-channel operation supported information element

Element ID	Length (bytes)	Value	Scope
xx	1	0x00: Multi-channel operation not supported. 0x01: Multi-channel operation supported. 0x02-0xFF: Reserved.	CBC-REQ, CBC-RSP

7.7.24 Confirmation codes

Following fields are inserted in Table 173 as follows:

Table 173—Confirmation Codes

CC	Status
0x13	reject-RS-not-supported-parameter-value
0x14–0xFF	*Reserved*

7.7.25 Local Cell Update

7.7.25.1 Local Cell Update REQ

The format of a Local Cell Update request message is shown in Table W1. This message shall be transmitted by a distributed scheduling R-CPEs to the MR-BS at the change of local cell information.

Table W1—Local Cell Update REQ message format

Syntax	Size	Note
Container_Message _Format() {		
Management Message Type = xx	8 bits	
Number of Contained Messages: n	8 bits	The number of contained messages
For (i=1; i<= n; i++){	Variable	
Message Type = xx	8 bits	Local Cell Update REQ
SID	13 bits	SID of CPE, which require local cell update request
Information elements (IEs)	Variable	7.7.7.3
}		
}		

7.7.25.2 Local Cell Update RSP

The format of a Local Cell Update response message is shown in Table X1. This message shall be transmitted by an MR-BS to a distributed scheduling R-CPEs for the confirmation of local cell update request.

Table X1—Local Cell Update RSP message format

Syntax	Size	Note
LocalCell_Update_RSP_Format() {		
Management Message Type = xx	8 bits	
Number of CPEs: n	8 bits	The number of CPEs, which update information in a local cell
For (i=1; i<= n; i++){	Variable	
SID	13 bits	SID

Table X1—Local Cell Update RSP message format

Syntax	Size	Note
Information elements (IEs)	Variable	
}		
}		

7.7.25.3 Local Cell Update information element

7.7.25.3.1 De-registration

The format of a de-registration IE is shown in Table Y1.

Table Y1—De-registration information element

Element ID	Length (bytes)	Value	Scope
xx	1	0; De-registerd	

7.7.26 Container Message

The format of a Container message is shown in Table Z1. A container message is used to convey management messages from the centralized scheduling R-CPE to the BS/MR-BS.

Table Z1—Container message format

Syntax	Size	Note
Container_Message _Format() {		
Management Message Type = xx	8 bits	
Number of Contained Messages: n	8 bits	The number of contained messages
For (i=1; i<= n; i++){	Variable	
Message Type = xx	8 bits	Local Cell Update REQ
SID	13 bits	SID of CPE, which require local cell update request
Information elements (IEs)	Variable	7.7.7.3

Table Z1—Container message format

Syntax	Size	Note
}		
}		

7.7.26.1 Container ACK Message

The format of a Container ACK message is shown in Table AA1. A container ACK message is used to acknowledgment for a container message sent to the centralized scheduling R-CPE from the BS/MR-BS.

Table AA1—Container ACK message format

Syntax	Size	Note
Container_ACKMessage _Format() {		
Management Message Type = xx	8 bits	
Number of Contained Messages: n	8 bits	
For (i=1; i<= n; i++){	Variable	
Message Type = xx	8 bits	The number of contained messages
SID	13 bits	SID of CPE, which require local cell update request
Confirmation Code	2 bits	0: success 1: unknown message 2: failed 3: reserved
}		
}		

7.7.27 Downstream Transit Test Message

7.7.27.1 Downstream Transmit Test (DTT) Request

The format of a DTT request message is shown in Table AB1.

Table AB1—DTT-REQ message format

Syntax	Size	Note
DTT-REQ_Message _Format() {		
Management Message Type = xx	8 bits	
Information elements (IEs)	Variable	
}		

7.7.27.1.1 Downstream Transmit Test (DTT) Request information element

The format of a DTT request IE is shown in Table AC1.

Table AC1—DTT-REQ information element

Name	Element ID (1 byte)	Length	Scope
SID		13 bits	Selected a centralized scheduling R-CPE to test a relay burst profile

7.7.27.2 Downstream Transmit Test (DTT) Response

The format of a DTT response message is shown in Table AD1.

Table AD1—DTT-RSP message format

Syntax	Size	Note
DTT-RSP_Message _Format() {		
Management Message Type = xx	8 bits	
Information elements (IEs)	Variable	
}		

7.7.27.2.1 Downstream Transmit Test (DTT) Response information element

The format of a DTT response IE is shown in Table AE1.

Table AE1—DTT-RSP information element

Name	Element ID (1 byte)	Length	Scope
Action Frame Number Offset	1	4 bits	Interger value greater than zero that indicates the starting frame number for a relay burst profile test
Status		2 bits	0: not allowed 1: success

7.7.27.3 Downstream Transmit Test (DTT) Report Message

The format of a DTT report message is shown in Table AF1.

Table AF1—DTT-RPT message format

Syntax	Size	Note
DTT-RPT_Message _Format() {		
Management Message Type = xx	8 bits	
Information elements (IEs)	Variable	
}		

7.7.27.3.1 Downstream Transmit Test (DTT) Report information element

The format of a DTT report IE is shown in Table AG1.

Table AG1—DTT-RPT information element

Name	Element ID (1 byte)	Length	Scope
Downstream burst profile	1	6 bits	Burst profile that can be received by the CPE

7.7.27.4 Downstream Transmit Test (DTT) Confirmation Message

The format of a DTT confirmation message is shown in Table AH1.

Table AH1—DTT-CFM message format

Syntax	Size	Note
DTT-CFM_Message _Format() {		
Management Message Type = xx	8 bits	
Information elements (IEs)	Variable	
}		

7.7.27.4.1 Downstream Transmit Test (DTT) Confirmation information element

The format of a DTT confirmation IE is shown in Table AI1.

Table AI1—DTT-CFM information element

Name	Element ID (1 byte)	Length	Scope
Confirmation Code		6 bits	0: Not allowed to transit 1: Need to re-test 2: allowed
Action Frame Number Offset		4 bits	Interger value greater than zero that indicates the starting frame number for a relay burst profile test

7.7.28 Relay-SCHE message

The format of a Relay SCHE message is shown in Table AJ1. This message may be used for the coordination of the uplink allocation. It is sent by an MR-BS to an R-CPE or sent by an R-CPE to an S-CPE.

Table AJ1—Relay-SCHE message format

Syntax	Size	Note
Relay-SCHE_Message _Format() {		
Management Message Type = xx	8 bits	
N_FID	8 bits	The number of FIDs included
For(i=0;i<N_FID;i++) {		
FID	8 bits	The FID for the CPE
Allocation Frame Offset	8 bits	In terms of number of frames
Bandwidth	8 bits	In number of bytes
}		

7.7.29 Channel Allocation Manager (CAM-AIF/STP/STP-ACK/SWH/SWH-ACK)

This clause describes the channel allocation manager management messages for the basic multi channel operations such as add new operating channel operation (CAM-AIF), stop operating channel (CAM-STP/STP-ACK)and switch operating channel (CAM-SWH/SWH-ACK).

7.7.29.1 Add new operating channel (CAM-AIF)

The format of the add new operating channel message is shown in Table AK1. This message is used to configure add new operating channel procedure during the multichannel operation. The aggregation information is needed by the CPE-CAM in order to identify the aggregation information transmitted from the BS-CAM. This message includes the number of maximum aggregation channel allowed and the channel aggregation information for CPE.

Table AK1—CAM-AIF message format

Syntax	Size	Note
CAM-AIF_Message_Format() {		
Management Message Type = 50	8 bits	
Aggregation Information	1 bit	0: Aggregation on 1: Aggregation off
Maximum Aggregation Channels	3 bits	The number of maximum aggregation channels allowed in CPE.
For (i=0;i < Maximum Aggregation Channels;i++){	3 bits	List of the channel informations that are available for channel aggregation in CPE.
Channel Number [i]	8 bits	
}		
}		

7.7.29.2 Stop operating channel (CAM-STP)

The format of the stop operating channel message is shown in Table AL1. This message is used to configure stop operating channel procedure during the multichannel operation. This message is sent by BS-CHU to the CPE-CHU in order to stop the operating channel in CPE-CHU. Transmission of this message may result from various conditions such as protection of incumbent services (BS incumbent sensing report, CPE incumbent sensing report), channel availability in database and BS channel scheduling.

Table AL1—CAM-STP message format

Syntax	Size	Note
CAM-STP_Message_Format() {		
Management Message Type = 51	8 bits	
Transaction ID	16 bits	
Confirmation Needed	1 bit	0: No confirmation needed 1: Confirmation needed

Table AL1—CAM-STP message format

Syntax	Size	Note
Stop Channel Number	8 bits	Specified destination for channel stop operation request.
}		

7.7.29.3 Stop operating channel acknowledgment (CAM-STP-ACK)

The format of the stop operating channel acknowledgment message is shown in Table AM1. This message shall be sent by CPE-CHU to the BS-CHU in response to a received CAM-STP. This message serves to confirm to the BS-CHU the reception of the CAM-STP message by the CPE-CHU.

Table AM1—CAM-STP-ACK message format

Syntax	Size	Note
CAM-STP-ACK_Message_Format() {		
Management Message Type = 52	8 bits	
Transaction ID	16 bits	
Confirmation Code	8 bits	7.7.24
}		

7.7.29.4 Switch operating channel (CAM-SWH)

The format of the switch operating channel message is shown in Table AN1. This message is used to configure switch operating channel procedure during the multichannel operation. This message is sent by BS-CHU to the CPE-CHU in order to switch the operating channel in CPE-CHU. Transmission of this message may result from various conditions such as protection of incumbent services (BS incumbent sensing report, CPE incumbent sensing report), channel availability in database and BS channel scheduling.

Table AN1—CAM-SWH message format

Syntax	Size	Note
CAM-SWH_Message_Format() {		
Management Message Type = 53	8 bits	
Transaction ID	16 bits	
Confirmation Needed	1 bit	0: No confirmation needed 1: Confirmation needed

Table AN1—CAM-SWH message format

Syntax	Size	Note
Switch Mode	1 bit	0: no restriction on transmission until the scheduled channel switch 1: addressed CPE shall transmit no further frames until the schedules channel switch.
Switch Count	8 bits	The number of frames until the BS sending the switching operating channel message switches to the new operating channel.
Switch Channel Number	8 bits	Specified destination for channel switch request.
}		

7.7.29.5 Switch operating channel acknowledgment (CAM-SWH-ACK)

The format of the switch operating channel acknowledgment message is shown in Table AO1. This message shall be sent by CPE-CHU to the BS-CHU in response to a received CAM-SWH. This message serves to confirm to the BS-CHU the reception of the CAM-SWH message by the CPE-CHU.

Table AO1—CAM-SWH-ACK message format

Syntax	Size	Note
CAM-SWH-ACK_Message_Format() {		
Management Message Type = 54	8 bits	
Transaction ID	16 bits	
Confirmation Code	8 bits	7.7.24
}		

7.7.30 Group Resource Allocation

7.7.30.1 Group Resource Allocation Configuration (GRA-CFG)

The format of Group Resource Allocation Configuration message is shown in Table AP1. This message is used to configure the group resource allocation. The BS uses this message to create a new group and ~~indicate~~ identify the devices that is belonging to a group.

The device bitmap size specifies the maximum number of devices that can be supported by a new group. The SID bitmap is used to indicate the device belonging to the group. The total size of the SID bitmap is the number of devices multiplied by 9 bits station ID. Each group is identified by a unique 12-bit group ID. The group is classified into two types, fixed group and portable or mobile group. The type of group is determined according to the mobility of H-CPE. The location of group is represented by the latitude and longitude of H-CPE.

Table AP1—GRA-CFG message format

Syntax	Size	Note
GRA-CFG_Message_Format() {		
Management Message Type = 55	8 bits	
Device Bitmap Size	4 bits	Maximum number of devices that can be included to a new group 0000: 1 0001: 2 0010: 4 0011: 8 0100: 16 0101: 32 0110: 64 0111: 128 1000~1111: Reserved
SID Bitmap	Variable (9 bits * number of devices)	The bitmap of station ID that is belonging to a new group
GID	12 bits	ID of the group to which the device is included
Group Type	1 bit	0: Fixed Group 1: Portable or Mobile Group
Group Location	48 bits	Latitude and longitude of a new group
}		

7.7.30.2 Group Resource Allocation Update (GRA-UPD)

The format of Group Resource Allocation Update message is shown in Table AQ1. This message is used to update the group resource allocation configuration. The device can be added to or deleted from a group.

Table AQ1—GRA-UPD message fomat

Syntax	Size	Note
GRA-UPD_Message_Format() {		
Management Message Type = 56		
Deletion Flag		Flag to indicate whether the device is added to or deleted from a group. 0: Added to a group 1: Deleted from a group

Table AQ1—GRA-UPD message fomat

Syntax	Size	Note
SID		Station ID that is added to or deleted from a group.
GID		Group ID to which the device is added to or deleted from a group.
If(Deletion Flag = 0) {		
Device Bitmap Index		Indicates the new index of the device in a group's device bitmap.
}		
}		

7.9 ARQ mechanism

7.9.6 ARQ operation

Insert new subclause 7.9.6.4:

7.9.6.4 ARQ for a relay network

In MR-WRAN systems, there are two ARQ modes. The first mode is an end-to-end ARQ mode that is performed between an MR-BS and an S-CPE; the second mode is a two-link ARQ mode that is performed both between an MR-BS and an R-CPE and between an R-CPE and an S-CPE. The support of ARQ mode is performed during the network entry.

In the end-to-end ARQ mode, the ARQ operation is same as the operations described in 7.9.6.1, 7.9.6.2 and 7.9.6.3. An R-CPE does not have an additional ARQ functionality.

In two-link ARQ mode, the ARQ operation is divided into two links that are a relay link between MR-BS and R-CPE and an access link between R-CPE and S-CPE. The detailed procedure for two-link ARQ mode is described in the 7.9.6.4.1.

7.9.6.4.1 Two-link ARQ mode

For an access link between R-CPE and S-CPE, the ARQ state machine runs between the R-CPE and the S-CPE. For relay link between MR-BS and R-CPE, the ARQ state machine runs between the MR-BS and the R-CPE. The MR-BS schedules retransmission to the R-CPE when ARQ block is corrupted in the relay link. The R-CPE schedules retransmission to the S-CPE when ARQ block is corrupted in the access link.

The ARQ feedback IE described in Table 176 is used by the MR-BS and R-CPE to ACK/NAK to corresponding data transmitted between MR-BS and R-CPE. The ARQ feedback IE is transported either as a packed payload ("piggybacked") within a packed MAC PDU or as a payload of a standalone MAC PDU defined in 7.6.

In downlink ARQ operation, when MR-BS sends ARQ block to R-CPE, it waits for the ARQ feedback IE from R-CPE. When ARQ block is corrupted in the relay link, the R-CPE sends NAK to MR-BS, and MR-BS schedules the retransmission of the corresponding ARQ block to R-CPE as shown in Figure F1. When MR-BS receives ACK from R-CPE, it waits for the ACK from the S-CPE relayed by R-CPE. R-CPE may modify the ARQ feedback IE received from S-CPE to inform only ACK to MR-BS. When MR-BS receives ACK from S-CPE, it clears the buffer corresponding to ARQ block as shown in Figure F1. When ARQ block is corrupted in the access link, R-CPE shall not send NAK to MR-BS and shall schedule the retransmission of ARQ blocks to S-CPE. R-CPE shall discard the ARQ block when ARQ block transmission failed in the access link after a timeout of the ARQ_BLOCK_LIFETIME. MR-BS or R-CPE discards the corresponding ARQ block after the timeout of its ARQ_BLOCK_LIFETIME. MR-BS and RS ARQ_BLOCK_LIFETIME are independently operated in MR-BS and R-CPE respectively.

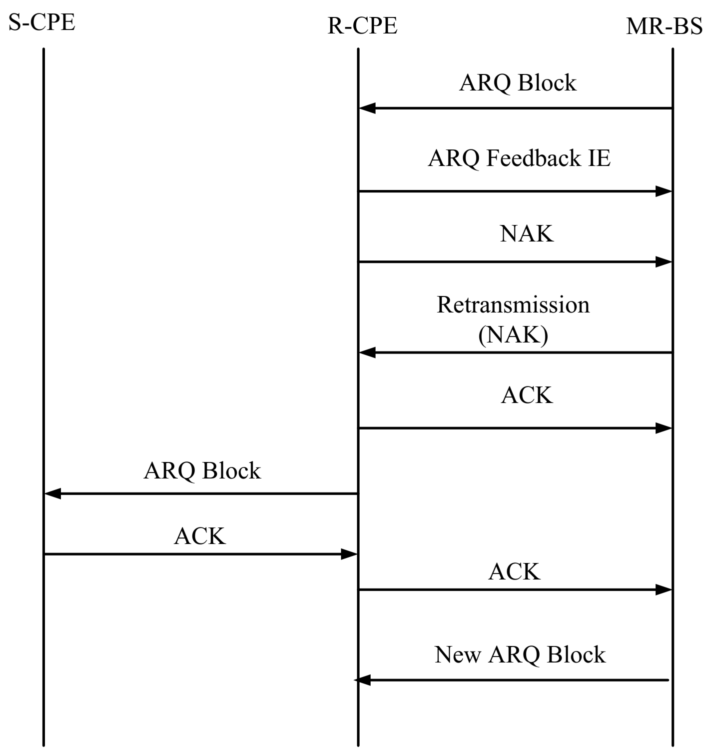

Figure F1—Example of downlink ARQ for relay

In uplink ARQ operation, when R-CPE receives ARQ block correctly from S-CPE, R-CPE sends ARQ block to MR-BS. When MR-BS receives ARQ block correctly, MR-BS sends ACK to R-CPE and the R-CPE sends ACK to S-CPE. When ARQ block is corrupted in the relay link, the retransmission shall be scheduled from R-CPE to MR-BS. R-CPE discards the corresponding ARQ block after a timeout of ARQ_BLOCK_LIFETIME in R-CPE.

7.9.6.4.2 ARQ State machine

The ARQ state machine operation in R-CPE and receiver in MR-BS is the same as described in 7.9.6.2 and 7.9.6.3. In case of transmitter state machine in MR-BS, an ARQ block may be in one of the following five states—not sent, outstanding for R-ACK, outstanding for S-CPE-ACK, waiting for retransmission, and data discard. Outstanding for R-ACK is the state waiting for receiving acknowledged from R-CPE. When R-ACK received, the state transits to outstanding for S-CPE-ACK. In this state, MR-BS receives S-CPE-NACK or after ARQ_BLOCK LIFE_TIME, the state transits to discard. If MR-BS receives S-CPE-ACK in the state of outstanding for R-ACK or waiting for retransmission, the state transits to done. Other state transition descriptions are the same as transmitter state machine defined in x.x.x. The ARQ Tx block state sequence in MR-BS is shown in Figure G1.

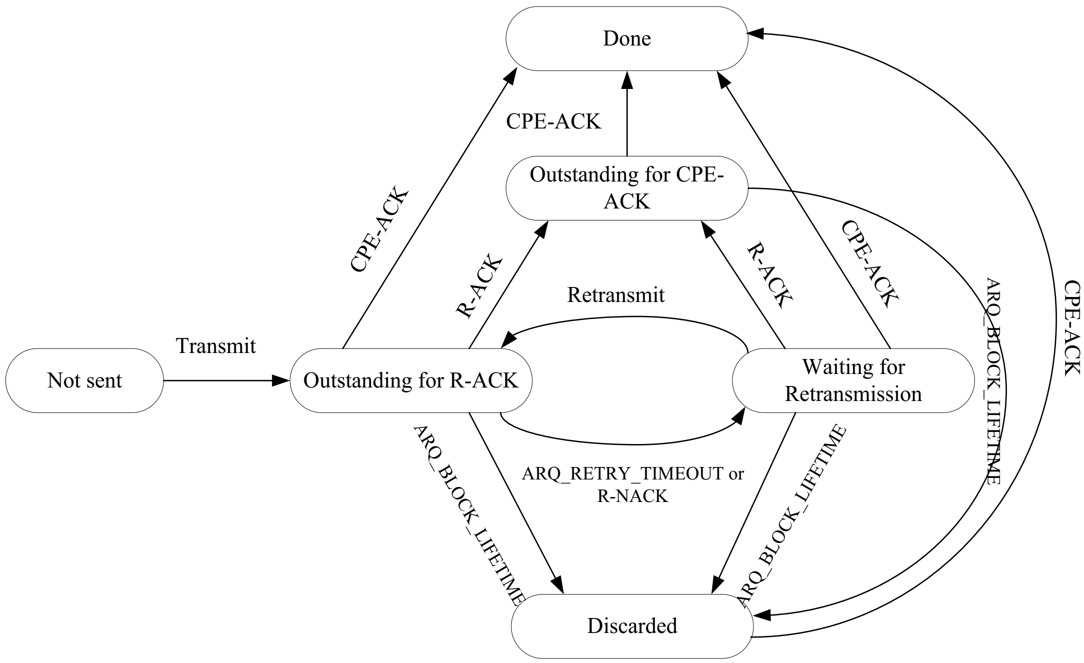

Figure G1—ARQ Tx block state in MR-BS

7.10 Scheduling services

7.10.2 Upstream request/grant scheduling

7.10.2.1 UGS

Insert the following paragraphs at the end of 7.10.2.1

In MR-WRAN systems, to meet a UGS service flow's need, the MR-BS and R-CPE along the path shall grant fixed size bandwidth to its S-CPE on a real-time periodic basis.

The MR-BS or the R-CPE may send RS scheduling information (Relay-SCHE, 7.7.28) in advance to its S-CPE to indicate when and how much bandwidth it will schedule for the service in the future.

7.10.2.2 rtPS

Insert the following paragraphs at the end of 7.10.2.2

In MR-WRAN systems, to meet an rtPS service flow's need, the MR-BS and R-CPE along the path shall poll its S-CPE or grant dynamic size bandwidth to its S-CPE on a real-time periodic basis.

The MR-BS or the R-CPE may send Relay scheduling information (Relay-SCHE, 7.7.28) to its S-CPE to indicate when it will schedule a poll in the future.

7.11 Bandwidth management

Insert new subclause 7.11.1a as follows:

7.11.1a Bandwidth Request for a relay network

In 802.22b systems, the bandwidth request message, mechanism, and capability defined for the CPE and MR-BS shall be applicable for the R-CPE. Capability of incremental BRs is only mandatory if the R-CPE is a distributed scheduling R-CPE.

7.11.1a.1 Bandwidth Request by a distributed scheduling R-CPE

A distributed scheduling R-CPE directly handles the bandwidth requests it receives from its S-CPEs.

A distributed scheduling R-CPE may receive bandwidth requests from its S-CPEs via the MAC signaling header, the grant management subheader or the CDMA bandwidth request code.

To forward upstream traffic to MR-BS, a distributed scheduling R-CPE may request uplink bandwidth via a stand-alone bandwidth request header. A distributed scheduling R-CPE may combine the bandwidth requests that arrive from S-CPEs together by using a Container message (7.7.26) or with the bandwidth needs of queued packets into one bandwidth request header per QoS class.

The distributed scheduling R-CPE may transmit a BW request header soon after it receives a BW request header from one of its S-CPEs (timed to yield an uplink allocation sequential to the arrival of those packets) instead of waiting for the actual packets to arrive in order to reduce delay in relaying traffic (see Figure H1).

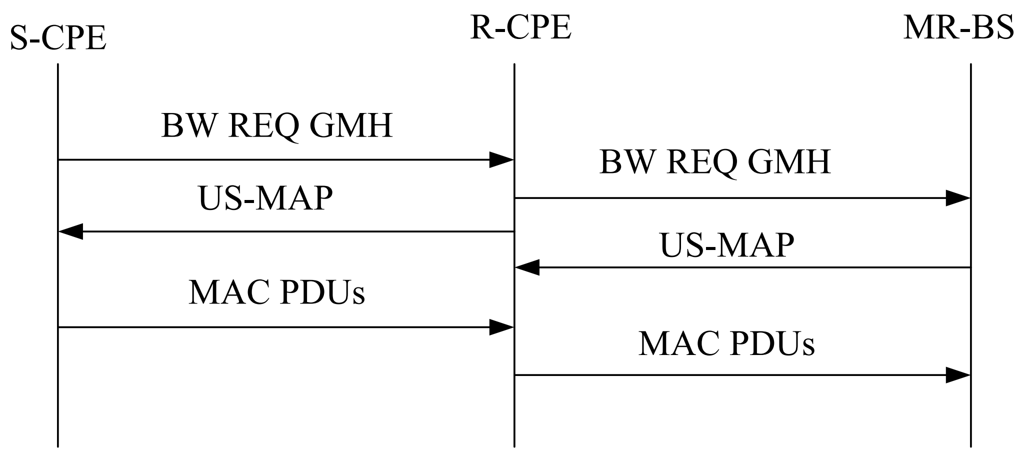

Figure H1—Reducing latency in relaying traffic by transmitting BW request header before packets arrive

7.11a.2 Bandwidth Request by a centralized scheduling R-CPE

In centralized scheduling mode, the MR-BS shall determine the bandwidth allocations (i.e., MAPs) for all links in its cell. As a result, centralized scheduling R-CPEs shall receive the MAPs from the MR-BS for the links to/from their CPEs before they can transmit them.

For the same reason, centralized scheduling R-CPEs shall forward all bandwidth request headers and bandwidth request CDMA ranging code information they receive from CPEs to the MR-BS. The centralized scheduling R-CPEs may combine bandwidth request by using a Container message (7.7.26).

If the centralized scheduling R-CPE has available uplink bandwidth, it shall simply forward the bandwidth request information to the MR-BS. Otherwise, the centralized scheduling R-CPEs shall request uplink bandwidth from the MR-BS using CDMA ranging codes.

If the centralized scheduling R-CPE needs bandwidth for a MAC management message to a CPE, the centralized scheduling R-CPE shall either send a CRZ CDMA ranging code dedicated for that purpose or a BR header. In response, the MR-BS shall allocate bandwidth for a management message in the DS-MAP it sends to the centralized scheduling R-CPE for broadcast.

7.11.2 Grants

Insert new subclauses 7.11.3a as follows:

7.11.3a Grants for a relay network

Insert new subclauses 7.11.3a.1 and 7.11.3a.2 as follows:

7.11.3a.1 Bandwidth grant for relay with a distributed scheduling R-CPE

If the bandwidth request comes from a distributed scheduling R-CPE, the MR-BS shall address the bandwidth grant to the R-CPE's Basic FID. The distributed scheduling R-CPE may schedule a MAC PDU or relay MAC PDU on the bandwidth allocation it receives.

An MR-BS may send its distributed scheduling R-CPEs uplink scheduling information ahead of time via an Relay-SCHE management message. This message indicates when a given uplink bandwidth allocation will be granted to the distributed scheduling R-CPE (i.e., in how many frames), the size of the allocation, and the intended CID. The actual bandwidth grant is issued to the distributed scheduling R-CPE using a Data Grant IE in an upcoming US-MAP. In the case of periodic bandwidth grants, the scheduling information need only be sent once (see Figure I1).

When a distributed scheduling R-CPE receives an Relay-SCHE management message with uplink scheduling information from the MR-BS, it shall look up the target CPE of the given FID. Based on this scheduling information and the target CPE of the FID, the distributed scheduling R-CPE can determine the appropriate bandwidth allocations and associated RS UL allocation frame offset on the uplinks it controls.

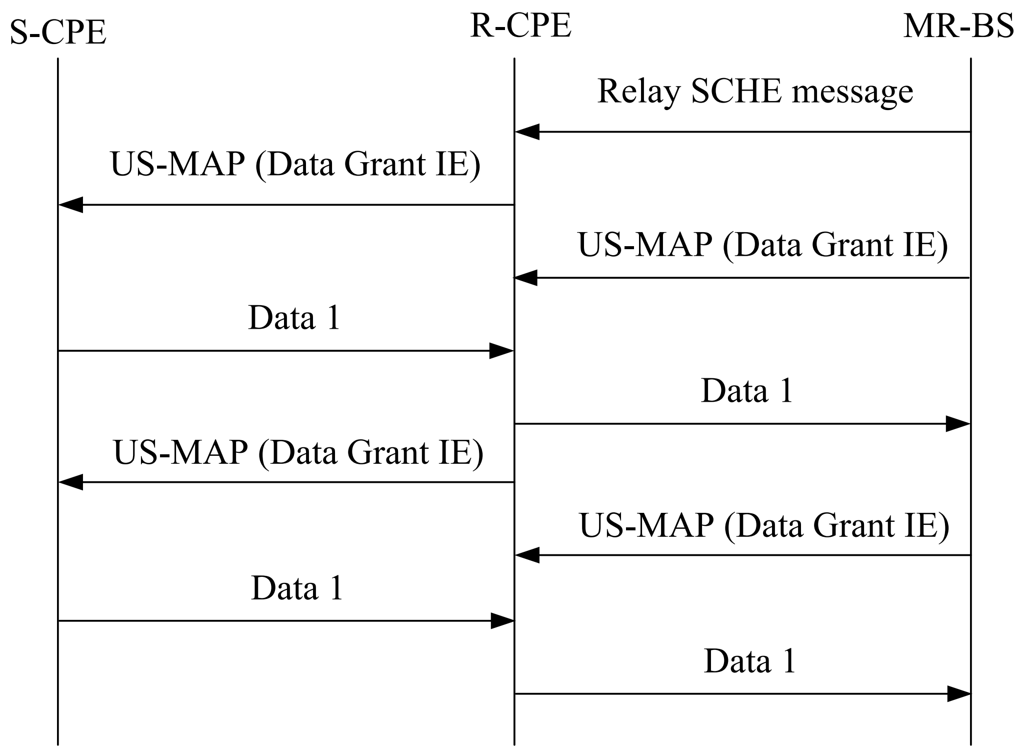

Figure I1—Periodic bandwidth grant with R-CPE scheduling information

7.11.3a.2 Bandwidth grant for Relay with a centralized scheduling R-CPE

For centralized scheduling, when an MR-BS allocates bandwidth to forward a packet to/from a given station, it shall allocate bandwidth on all links (relay and access) that make up the path to/from that station taking into account the processing delay and link qualities at each R-CPE.

7.11.4 Polling

Insert new subclause 7.11.4.1 as follows:

7.11.4.1 Polling for a relay network

The polling procedure defined in 7.11.3 for the CPE and the MR-BS may be used between the CPE/R-CPE. If an R-CPE is regularly polled, it can transmit a bandwidth request header to the MR-BS as soon as it detects impending uplink traffic in order to reduce delay (see Figure J1).

An MR-BS or a distributed scheduling R-CPE may inform a CPE of upcoming polling via an Relay SCHE management message (see Figure K1).

For centralized scheduling, only the MR-BS may establish a polling process with a CPE or centralized scheduling R-CPE in the MR-cell.

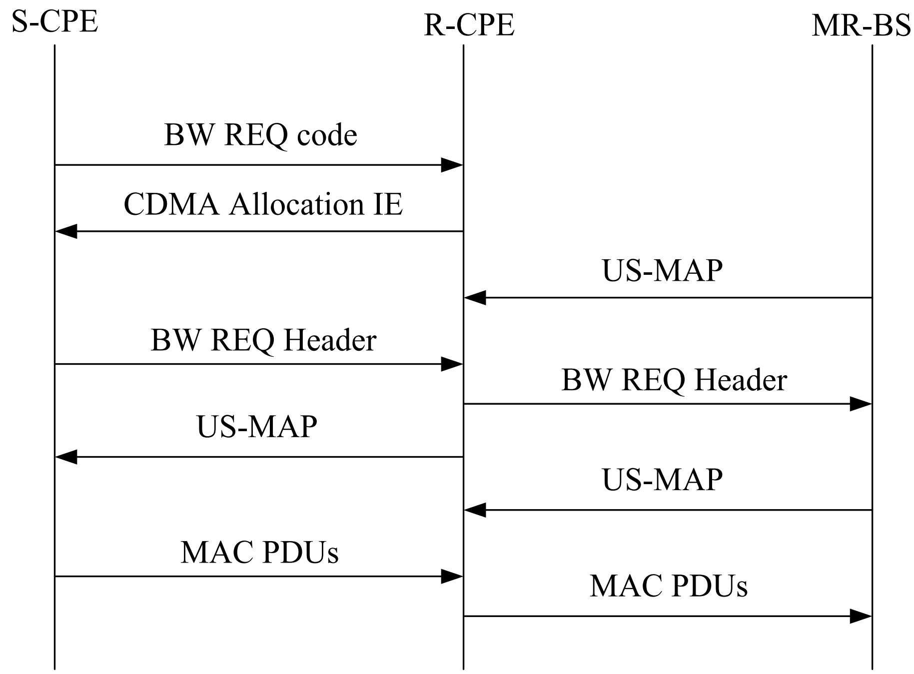

Figure J1—Reducing latency in relaying traffic via R-CPE polling

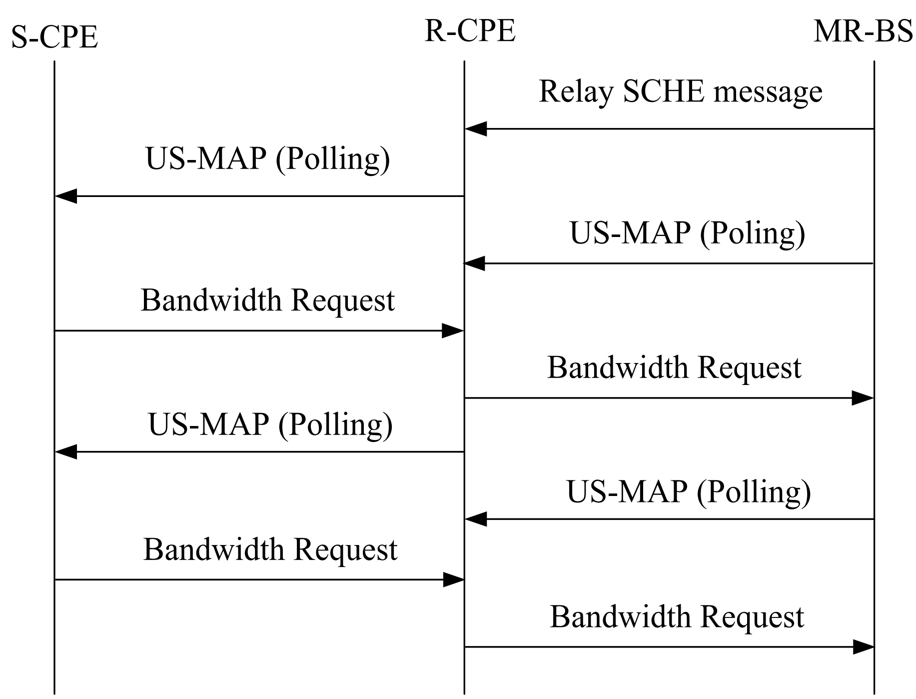

Figure K1—Periodic polling with R-CPE scheduling information

7.12 PHY support

7.13Contention resolution

Change the paragraph as follows:

The BS, MR-BS or distributed scheduling R-CPE controls assignments on the upstream channel through the US-MAP messages and determines which symbol periods are subject to collisions. Collisions may occur during Initial Ranging/Relay Initial Ranging/Local Initial Ranging, Periodic Ranging/Relay Periodic Ranging/Local Periodic Ranging, Bandwidth Request/Relay Bandwidth Request/Local Bandwidth Request, UCS notification/Relay UCS notification/Local UCS notification, and the SCW defined by their respective IEs. The potential occurrence of collisions in the Intervals is dependent upon the number of SIDs whose US-MAP IEs are (simultaneously configures to use an Interval for a specific purpose (e.g., Ranging, UCS notification, BW Request). The CPE has to make a decision in order to resolve collision in the upstream direction for Initial Ranging/Relay Initial Ranging/Local Initial Ranging, Periodic Ranging/Relay Periodic Ranging/Local Periodic Ranging, and BW Request/Relay Bandwidth Request/Local Bandwidth Request. Since in the case of UCS notification/Relay UCS notification/Local UCS notification and SCW (CBP packet transmission in the SCW) no explicit feedback is expected to be received from the BS, MR-BS or distributed scheduling R-CPE, collision resolution does not apply.

Change the paragraph as follows:

In the case of Initial Ranging/Relay Initial Ranging/Local Initial Ranging and Periodic Ranging/Relay Periodic Ranging/Local Periodic Ranging, collision resolution is to be done by a CDMA method (see Table 31 and Table 37). In the case of Bandwidth Request/Relay Bandwidth Request/Local Bandwidth Request and UCS notification/Relay UCS notification/Local UCS notification, ~~both~~those methods, CDMA as well as exponential time backoff, explained later in this subclause, can be used. In the case of collision resolution in the SCW, a special scheduling scheme, described in 7.20.1.2, shall be used. Since a CPE may need to service multiple upstream service flows (each with its own FID), it makes these decisions on a per FID or on a QoS (see 7.17) basis. The method of contention resolution that shall be supported for BW Request/Relay Bandwidth Request/Local Bandwidth Request and UCS notification/Relay UCS notification/Local UCS notification ~~is~~are based on a truncated binary exponential backoff, with the initial backoff window and the maximum backoff window controlled by the BS, MR-BS or distributed scheduling R-CPE (see Table 30). The values, expressed in units of opportunity (see Table 31) are specified as part of the UCD message and represent a power-of-two value. For example, a value of 4 indicates a window between 0 and 15 opportunities; a value of 10 indicates a window between 0 and 1023 opportunities. When a CPE has information to send and wants to enter the contention resolution process, it sets its internal backoff window equal to the BW Request or UCS Notification Backoff Start defined in the UCD message referenced by the UCD Count in the US-MAP message currently in effect (the map currently in effect is the map whose allocation start time has occurred but which includes IEs that have not occurred).

Note that the number of these opportunities per frame depends on the size of the opportunity window in number of subchannels defined by the US-MAP for UIUC 2 or 3 (see Table 35) and the opportunity size for the BW Request/Relay Bandwidth Request/Local Bandwidth Request and UCS notification/Relay UCS notification/Local UCS notification defined in Table 31. These opportunities shall be mapped horizontally in the time domain and fill a subchannel before moving to the next subchannel as is done for the upstream data PDU mapping.

7.13.1 Transmission opportunities

Change the paragraph as follows:

A transmission opportunity is defined as an allocation provided in a US-MAP or part thereof intended for a group of CPEs authorized to transmit initial ranging requests/relay initial ranging requests/local initial ranging requests, periodic ranging requests/relay periodic ranging requests/local periodic ranging requests, bandwidth requests/relay bandwidth requests/local bandwidth requests, or UCS notifications/relay UCS notifications/local UCS notifications. This group may include either all CPEs that have an intention to join the cell or all registered CPEs or a multicast polling group. The number of transmission opportunities associated with a particular IE in a map is dependent on the total size of the allocation as well as the size of an individual transmission.

7.14 Initialization and network association

Insert new subclause 7.14.3 as follows:

7.14.3 CPE initialization for relay

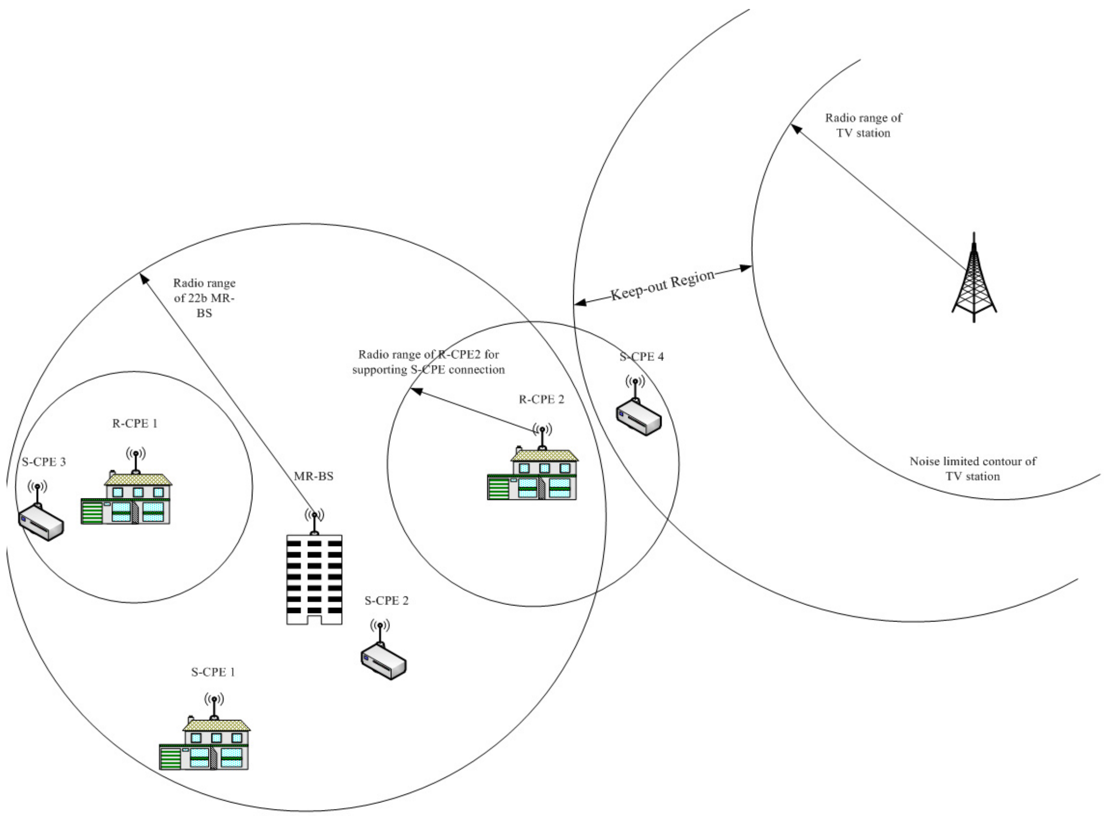

Figure L1—MR-WRAN scenario where a safe bootstrap operation is required to protect incumbents

Figure L1 illustrates an MR-WRAN scenario where the need for the definition of an incumbent safe CPE initialization can be easily seen. In this figure, consider that S-CPE 4, which is located outside of a MR-BS's cell but located within a distributed scheduling R-CPE 2's local cell, is powered down whereas the MR-BS is transmitting in the cell and R-CPE 2 being a member of the MR-BS is transmitting in the local cell that are under normal operation. Further, assume that the TV station in Figure L1 is powered up and starts transmitting in the same channel (i.e., channel #N in this example) that is being used by the MR-BS and R-CPE 2 for their transmissions in the cell. S-CPE 4 should be capable of detecting that R-CPE 2 is operating in a channel that is occupied by an incumbent service. The MR-BS must be capable of determining if S-CPE 4 is located within interference range of the TV station protected contour (i.e., in the keep-out region). If S-CPE 4 is already registered with the network managed by the R-CPE 2, it will alert the R-CPE 2. If S-CPE 4 is not registered with the network, it shall not transmit. See 10.2.5, policies 5 and 6. In the response to the alert from S-CPE 4, the SM at R-CPE 2 performs to detect TV station and shall sends the notification of detecting TV station to the MR-BS. In response to the notification from R-CPE 2, the SM at the MR-BS may or may not decide to switch channel to accommodate the connected CPEs (see 10.2.6.6). The purpose of the sensing and geolocation capabilities of the WRAN system shall be to prevent harmful interference to the primary TV service by providing the necessary information to the MR-BS's SM that generates the list of available channels. The definition of an incumbent safe CPE initialization phase is critical for cognitive radio systems. The SM incorporates algorithms to address this need (see Table 234, policies 5 and 6).

First and foremost, the MAC does not presuppose any preassigned channel where a CPE is able to look for an MR-BS or a distributed scheduling R-CPE given the time-varying and unpredictable nature of channel occupancy. Hence, the first task a CPE must perform in attempting to join a network is to scan the set of channels for MR-BSs or R-CPEs and incumbent services on which the transmissions of the CPE might interfere. Since the MR-BS shall send concentrated OFDM symbols composed of a frame preamble and SCH once every superframe in PHY mode 1, or a frame preamble and an FCH once every frame in PHY mode 2 in its operating channel, and the distributed scheduling R-CPE shall send concentrated OFDM symbols composed of a local frame preamble and a DRZ-FCH in the downstream DRZ subframe within a frame, if available, in its operating channel (see 7.3), the CPE will recognize the existence of an MR-BS or a distributed scheduling R-CPE transmission and, if appropriate, proceed with the CPE initialization procedure with the corresponding MR-BS or distributed scheduling R-CPE. Although a CPE will recognize the existence of an MR-BS, in particular, the CPE may not be initialized with the MR-BS directly since the transmission of the CPE is not able to reach the MR-BS due to the power constraint. In this case, the CPE will make an initialization by relaying on a centralized scheduling R-CPE.

The procedure carried out by the MR-BS, the centralized scheduling R-CPE, the distributed scheduling R-CPE and the CPE to perform CPE network entry and initialization shall be as follows:

a) CPE performs self test.
b) CPE acquires the antenna gain information.
c) CPE senses for and synchronizes to WRAN services. The sensing thread also begins during this step to detect broadcasting incumbents.
d) CPE presents sensing results to the higher layers.
e) CPE chooses a WRAN service.
f) If CPE is capable of geolocation, CPE acquires valid geolocation data from the satellites. If the data acquisition is unsuccessful, CPE initialization should not continue or may continue to operate as an S-CPE mode. If CPE is not capable of geolocation, CPE initialization should not continue or may continue to operate as an S-CPE mode (FCC Mode I).
g) CPE acquires the downstream and upstream parameters from the selected WRAN service.
h) CPE directional antenna azimuth adjustment.
i) If channels N and N±1 pass the sensing and timing requirements, CPE perform initial ranging (see 7.15.2.1).
j) CPE transmits basic capabilities.
k) If all required basic capabilities are present in the CPE, the AAA authenticates the CPE and key exchange is performed; otherwise, the CPE does not proceed to registration and the MR-BS deregisters the CPE.
l) Perform Registration (REG-REQ/RSP).
m) Upon completing registration, MR-BS transmits channel sets to CPE.
n) Establish IP connectivity.
o) Establish time of day.
p) Transfer operational parameters.

q) Establish dynamic service flows.

r) CPE reports sensing results and discovered neighboring networks.

Figure M1 summarizes the network entry of the CPE and its initialization procedure. Note that these steps taken by the CPE consist of a set of actions and error verification. In the following subclauses, a more detailed description of these steps and their individual responsibilities are provided.

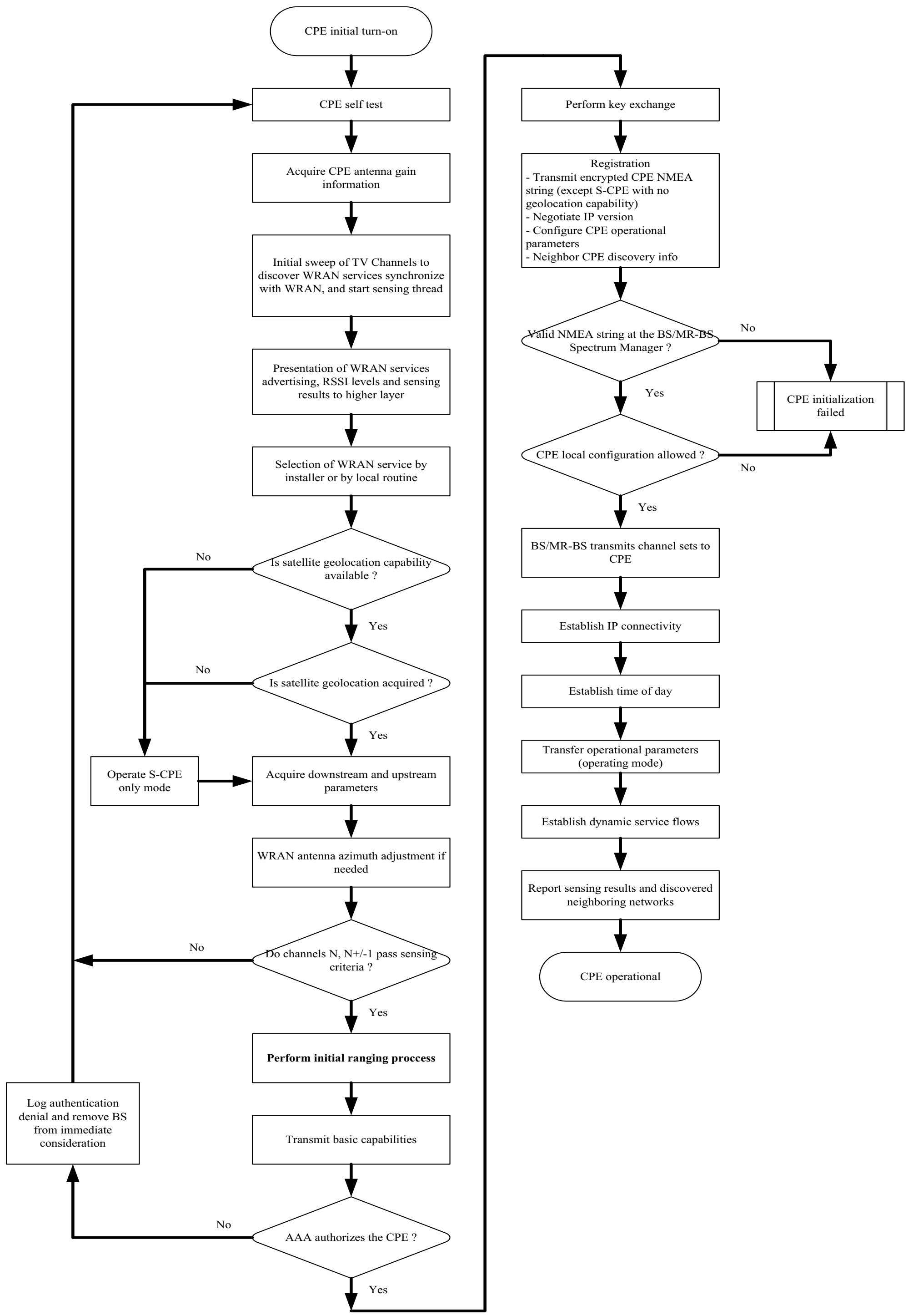

Figure M1—CPE initialization procedure

7.14.3.1 CPE performs self test

On initialization or after signal loss, the CPE shall perform a self test.

7.14.3.2 CPE antenna gain information acquisition

The CPE shall determine if its antenna is integrated or not by querying it using the M-ANTENNA- INTEGRATED primitive structure described in 10.7.6.1 and 10.7.6.2. The CPE shall acquire the antenna information including the maximum antenna gain information for the channels that can be used in the regulatory domain of interest. This information is stored in a MIB, *wranIfBsCpeAntennaGainTable*. If the antenna is integrated to the CPE TRU, this MIB object shall be pre-populated by the manufacturer of the CPE. If the antenna is not integrated into the CPE TRU, the MIB object shall be populated by querying the AU through the interface defined in 9.12.2. The information at the antenna shall be pre-populated by the antenna manufacturer.

7.14.3.3 CPE senses for and identifies WRAN services and incumbents

The CPE identifies WRAN services from detecting the MR-BS or the distributed scheduling R-CPE. The CPE shall perform spectrum sensing to detect the MR-BS or the distributed scheduling R-CPE, and may perform spectrum sensing to detect and identify legitimate incumbent services that are to be protected on each active WRAN channel in the area and its adjacent channels as described in 10.3.2.

7.14.3.4 Present sensing results to the higher layers

As a result of spectrum sensing, the available MR-BSs or distributed scheduling R-CPEs in the area are presented to the application layer program via connection C2 and MIBs through M-SAP as shown in IEEE 802.22 reference architecture (Figure 7). The application may be running on the CPE or on an attached computer. The data presented includes the operating channel of the MR-BS and RSSL in addition to the WRAN service being advertised.

7.14.3.5 CPE chooses a WRAN service

A WRAN service is selected at the higher layers of the CPE after preliminary sensing and identification of available MR-BSs or distributed scheduling R-CPEs and the presence of incumbents in the area as the previous subclauses describe. The CPE SSA shall issue an M-WRAN-SERVICE-REPORT primitive to request the higher layers through the NCMS to select a channel from the available WRAN service list that is included in the primitive, as described in 10.7.4.1. The SSA shall receive an M-WRAN-SERVICE-RESPONSE primitive with the selected channel from the NCMS, as described in 10.7.4.3. Once the channel is selected, it and its adjacent channels are more rigorously sensed in order to detect the presence of a weak incumbent service that might be masked by the selected WRAN service. This procedure is described in more detail in 10.3.2.

7.14.3.6 CPE performs satellite-based geolocation

The CPE shall acquire geolocation data from a satellite-based geolocation receiver when it will operate as a fixed mode or as a distributed scheduling R-CPE (which is a mode II defined in FCC regulation). A CPE shall not progress to the next step of initialization for the fixed mode operation or the distributed scheduling R-CPE operation until the satellite-based geolocation technology successfully establishes lock and acquires valid geolocation data from the satellites. The CPE sends the NMEA string to the MR-BS during registration (see 7.14.3.11).

7.14.3.7 Acquire downstream and upstream parameters

There are two methods for acquiring downstream and upstream parameters; acquire downstream and upstream parameters from a MR-BS and acquire downstream and upstream parameters from a distributed scheduling R-CPE.

7.14.3.7.1 Obtaining downstream parameters from an MR-BS

The MAC shall search for the SCH for PHY mode 1 (Clause 9) or FCH for PHY mode 2 (Clause 9a) from the MR-BS, which indicates the beginning of the frame in normal mode, and the allocated frame in self-coexistence mode. To improve the joining latency, the CPE shall use energy detection to help ascertain about the presence/absence of a MR-BS in a particular channel. If the energy detected is below the detection threshold, the CPE can safely move to the next channel.

After having received SCH or FCH in a channel, the CPE shall perform sensing not only in the detected operating channel, but also in all other affected channels. During this sensing, the CPE shall attempt to identify incumbent operation. If incumbents are detected on the operating channel or either first adjacent channel, the MAC shall cause the CPE to cease transmitting application traffic on the channel and, at the first transmit opportunity send a short control message to the MR-BS indicating that it is using a channel occupied by an incumbent. In case the MR-BS receives such notification, it may take numerous actions as described in Figure 96. The aggregate duration of the short control messages shall not exceed the Channel Closing Transmission Time (see Table 276) of transmissions by the WRAN system before remedying the interference condition (changing channels, backing off transmit EIRP, terminating transmissions, etc.).

Provided no incumbents are found, the CPE may proceed to the next step. Here, the MAC shall search for the DS-MAP MAC management messages. The CPE achieves MAC synchronization once it has received at least one DS-MAP message. A CPE MAC remains in synchronization as long as it continues to successfully receive the FCH, DS-MAP, and DCD messages for its channel(s). If the Lost DS-MAP Interval (Table 273) has elapsed without a valid DS-MAP message or the T1 interval (Table 273) has elapsed without a valid DCD message or Lost FCH counts of FCH are missed, a CPE shall try to re-establish synchronization. The process of acquiring synchronization is illustrated in Figure N1. The process of maintaining synchronization is illustrated in Figure O1.

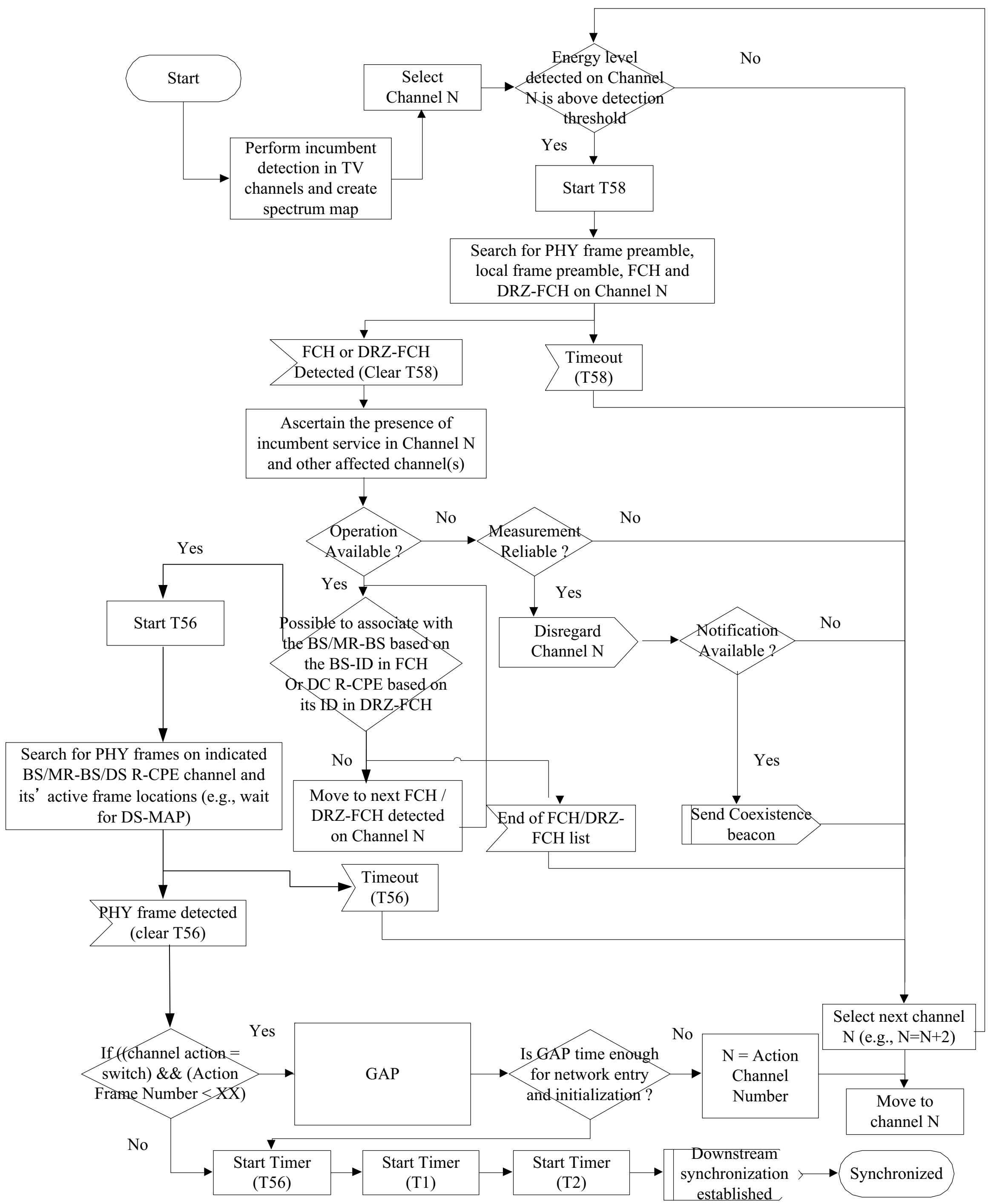

Figure N1—Obtaining downstream parameters

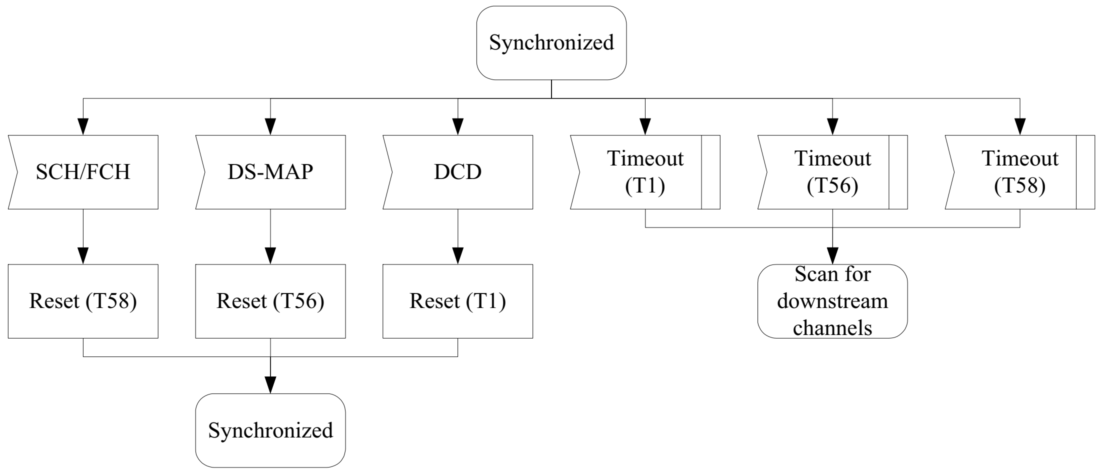

Figure O1—Maintaining downstream parameters

7.14.3.7.2 Obtaining downstream parameters from a distributed scheduling R-CPE

As another method to obtain downstream parameters, the MAC may search for a DRZ-FCH (7.5.2b) transmitted from a distributed scheduling R-CPE, which indicates the beginning of the distributed relay zone (7.4b.3.3) of downstream.

After having received a DRZ-FCH in a channel, the CPE shall perform sensing not only in the detected operating channel but also in all other affected channels. During this sensing, the CPE shall attempt to identify incumbent operation. If incumbents are detected on the operating channel or either first adjacent channel, the MAC shall cause the CPE to cease transmitting application traffic on the channel and, at the first transmit opportunity in a distributed relay zone (DRZ) of upstream send a short control message to the distributed scheduling R-CPE indicating that it is using a channel occupied by an incumbent. In case that the distributed scheduling R-CPE receives such notification, it shall send a short control message to the MR-BS. In case the MR-BS receives such notification, it may take numerous actions as described in Figure 96. The aggregate duration of the short control messages shall not exceed the Channel Closing Transmission Time (see Table 276) of transmissions by the WRAN system before remedying the interference condition (changing channels, backing off transmit EIRP, terminating transmissions, etc.).

Provided no incumbents are found, the CPE may proceed to the next step. Here, the MAC shall search for the DS-MAP MAC management messages, which are transmitted from the distributed scheduling R-CPE, in a DRZ of downstream. The CPE achieves MAC synchronization to the distributed scheduling R-CPE once it has received at least one DS-MAP message. A CPE MAC remains in synchronization as long as it continues to successfully receive the DRZ-FCH, DS-MAP, and DCD messages for its channel(s) within a DRZ. If the lost DS-MAP Interval (Table 273) has elapsed without a valid DS-MAP message or the T1 interval (Table 273) has elapsed without a valid DCD message or lost DRZ-FCH counts of DRZ-FCH are missed, a CPE shall try to re-establish synchronization. The process of acquiring synchronization is illustrated in Figure N1. The process of maintaining synchronization is illustrated in Figure P1.

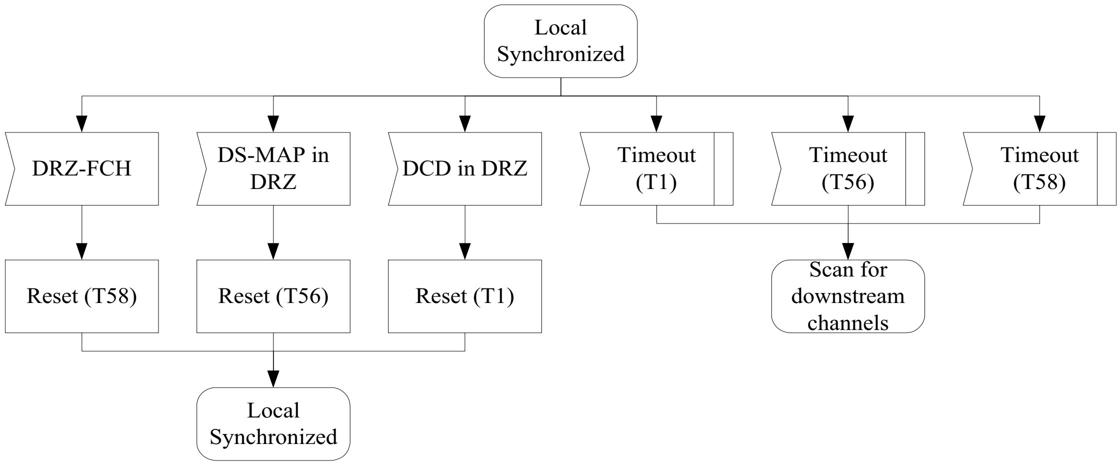

Figure P1—Maintaining downstream parameters in DRZ

7.14.3.7.3 Obtaining upstream parameters from an MR-BS

After synchronization to the MR-BS, the CPE shall wait for a UCD message from the MR-BS in order to retrieve a set of transmission parameters for a possible upstream channel. These messages are transmitted periodically from the MR-BS for all available upstream channels and are addressed to the MAC broadcast address.

If no upstream channel can be found after a suitable timeout period, then the CPE shall continue scanning to find another downstream channel. The process of obtaining upstream parameters is illustrated in Figure 37.

The CPE shall determine from the channel description parameters whether it may use the upstream channel. If the channel is not suitable, then the CPE shall continue scanning to find another downstream channel. If the channel is suitable, the CPE shall extract the parameters for this upstream from the UCD. It then shall wait for the next DS-MAP message and extract the time synchronization from this message. Then, the CPE shall wait for a bandwidth allocation map for the selected channel. It may begin transmitting upstream in accordance with the MAC operation and the bandwidth allocation mechanism.

The CPE shall perform initial ranging at least once. If initial ranging is not successful, the procedure is restarted from scanning to find another downstream channel.

The CPE MAC is considered to have valid upstream parameters as long as it continues to successfully receive the SCH/FCH, US-MAP, and UCD messages. If at least one of these messages is not received within the time intervals specified in Table 273, the CPE shall not use the upstream. This is illustrated in Figure Q1.

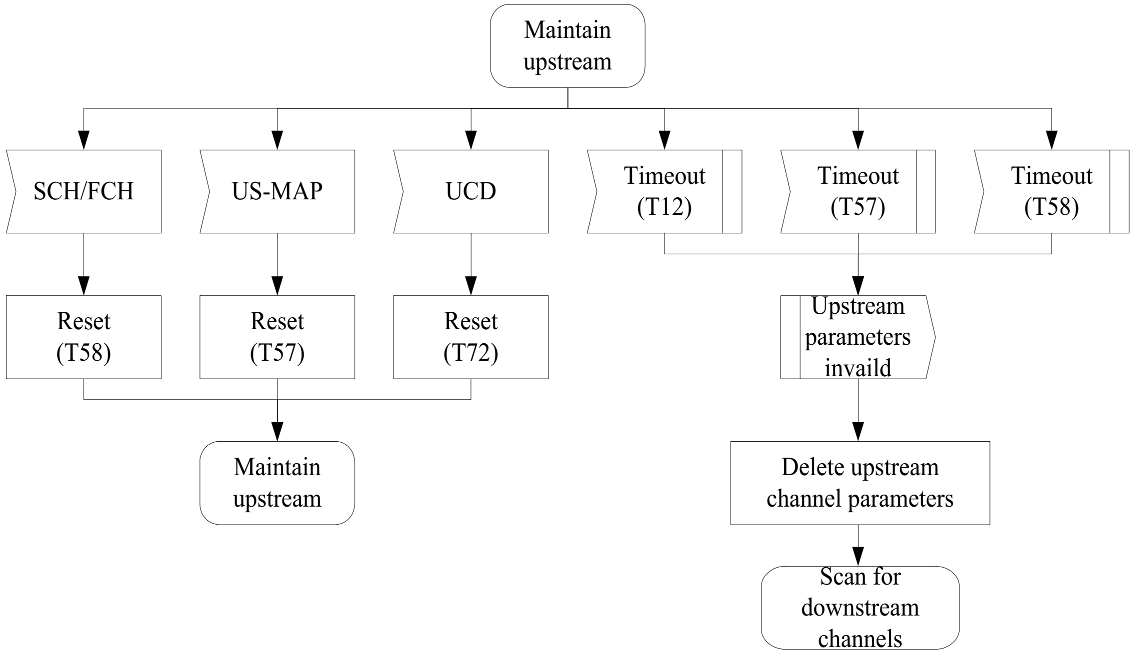

Figure Q1—Maintaining upstream parameters

7.14.3.7.4 Obtaining upstream parameters from a distributed scheduling R-CPE

After synchronization to the distributed scheduling R-CPE, the CPE shall wait for a UCD message from the distributed scheduling R-CPE in order to retrieve a set of transmission parameters for a possible upstream channel. These messages are transmitted periodically in a DRZ of downstream from the distributed scheduling R-CPE for the available upstream channels and are addressed to the MAC broadcast address.

If no upstream channel can be found after a suitable timeout period, then the CPE shall continue scanning to find another downstream channel. The process of obtaining upstream parameters is illustrated in Figure 37.

The CPE shall determine from the channel description parameters whether it may use the upstream channel. If the channel is not suitable, then the CPE shall continue scanning to find another downstream channel. If the channel is suitable, the CPE shall extract the parameters for this upstream from the UCD. It then shall wait for the next DS-MAP message and extract the time synchronization from this message. Then, the CPE shall wait for a bandwidth allocation map for the selected channel. It may begin transmitting upstream in accordance with the MAC operation and the bandwidth allocation mechanism.

The CPE shall perform initial ranging to the distributed scheduling R-CPE at least once. If initial ranging is not successful, the procedure is restarted from scanning to find another downstream channel.

The CPE MAC is considered to have valid upstream parameters as long as it continues to successfully receive the DRZ-FCH, US-MAP, and UCD messages. If at least one of these messages is not received within the time intervals specified in Table 273, the CPE shall not use the upstream. This is illustrated in Figure R1.

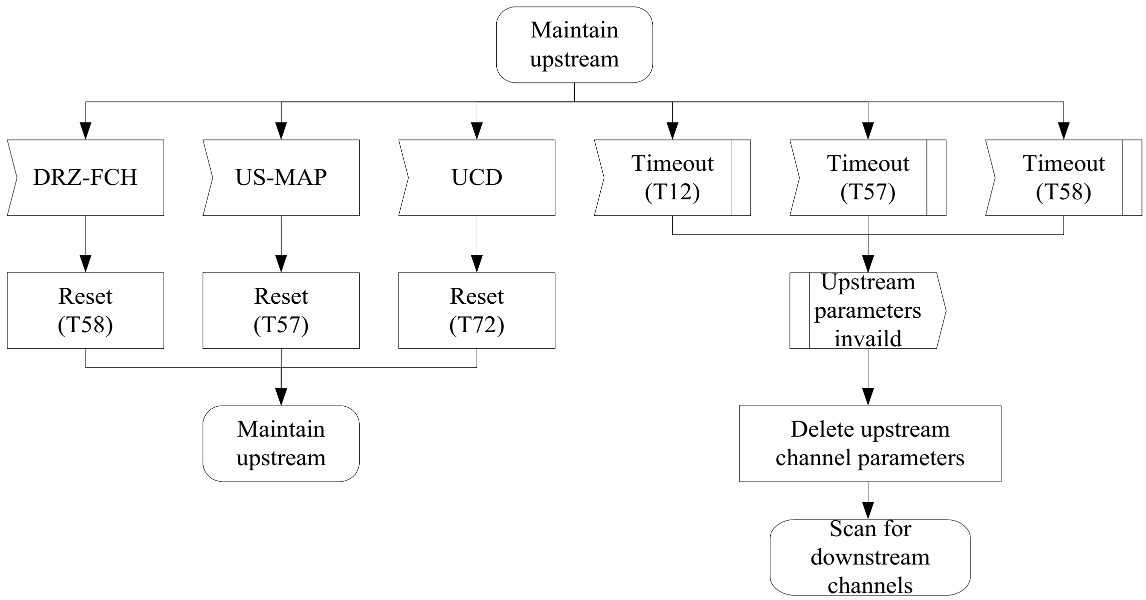

Figure R1—Maintaining upstream parameters in DRZ

7.14.3.8 CPE transmits ranging/CDMA burst

From the result of synchronization as described in 7.14.3.7, initial ranging will be performed. There are three methods of CPE transmit initial ranging; initial ranging to a MR-BS, initial ranging to a distributed scheduling R-CPE, and initial ranging to a centralized scheduling R-CPE on relaying.

The selected channel is analyzed to determine if it passes the restrictions specified in 10.3.2. If the selected channel does not pass these restrictions, the association with the selected MR-BS or distributed scheduling R-CPE is unsuccessful and the selected channel shall be removed from further consideration. Available MR-BSs or distributed scheduling R-CPEs are again presented to the higher layers for selection if there exists any other MR-BSs or distributed scheduling R-CPEs with which to associate.

Next the selected channel and the channels that could be harmfully interfered by operation on this selected channel shall be more finely sensed as to determine if there exists a weak protected incumbent signal that was not detected at an earlier stage in the CPE initialization procedure. This process is described in 10.3.2.

Time in this subclause shall be referenced to two positions in space. One position will be that of the MR-BS or distributed scheduling R-CPE and the other position will be that of the CPE. Many such CPE positions will exist. Ranging is the process of acquiring the correct timing offset and EIRP adjustments such that the CPE's transmissions are aligned at the MR-BS or distributed scheduling R-CPE position. Ranging also adjusts transmit EIRP of the various CPEs such that the OFDMA signal received at the MR-BS or distributed scheduling R-CPE arrives with compatible amplitudes from all the CPEs.

Although a CPE successfully obtains downstream parameters from a MR-BS, in particular, ranging to the MR-BS as described in 7.14.3.8.1may be failed due to the CPE transmitting power constraint. However, the CPE is still able to have an uplink transmission to the MR-BS by relaying on a centralized scheduling R-CPE. In this case, the CPE may perform ranging to a centralized scheduling R-CPE for the relaying operations that acquiring the correct timing offset and EIRP adjustments aligned at the centralized scheduling R-CPE.

The timing delays through the PHY shall be constant to within 25% of the shortest symbol cyclic prefix as indicated in 9.9.1.

7.14.3.8.1 CDMA initial ranging and automatic adjustments to an MR-BS

First, a CPE shall synchronize to the frame preamble in order to perform initial ranging to MR-BS. At this point, the CPE shall scan the US-MAP message to find an Initial Ranging Interval. The MR-BS may allocate an Initial Ranging Interval consisting of one or more transmission opportunities. The CPE shall extract the number of initial ranging codes (see Table 31, element ID 150) from the UCD MAC management message.

The CPE randomly selects the CDMA code as described in 7.15.2.1a and sends the initial ranging CDMA code on the US allocation dedicated for that purpose. The MR-BS receives the CDMA code. As many CPEs may contend for ranging, the CDMA code received may be the sum of many CPE transmissions. The MR-BS isolates each of these transmissions and computes the ranging adjustments based on the relative time of arrival of each CPE upstream burst, i.e., the timing offset, so that all these bursts arrive at the MR-BS at the beginning of the symbol period within sufficient tolerance.

Ranging adjusts each CPE's timing offset such that each CPE appears to be co-located with the MR-BS. The CPE shall set its initial timing offset to "zero advance" as if it was physically co-located with the MR-BS. When the Initial Ranging transmission opportunity occurs, the CPE shall send a CDMA code. After reception and decoding of this CDMA code, the MR-BS will react by sending a RNG-CMD MAC message in a following frame with the same CDMA code and indicate the timing advance that the CPE should use for its upstream transmissions (see Table 44) so that the beginning of its bursts is aligned with the center of the cyclic prefix within the tolerance indicated in 9.9.1.

When the Initial Ranging transmission opportunity occurs, the CPE shall send a CDMA code. Thus, the CPE sends the message as if it were co-located with the MR-BS.

The CPE shall calculate the transmit EIRP per subcarrier for initial ranging, $EIRP_{IR\_CPE}$, from the following equation:

$$EIRP_{IR\_CPE} = EIRP_{MR\text{-}BS} + RSS_{IR\_MR\text{-}BS\_nom} - (RSS_{IR\_CPE} - G_{RX\_CPE}) + 10\times\log(N_{IR\_sub}/N_{sub})$$

where

$RSS_{IR\_MR\text{-}BS\_nom}$ and $EIRP_{MR\text{-}BS}$ are defined in a DCD IE (see Table 23)

G_{RX_CPE} is the antenna gain at the CPE

RSS_{IR_CPE} is the RSSL measured by the CPE, which is then corrected by the CPE antenna gain to represent the RSSL for an isotropic antenna

N_{IR_sub} is the number of subcarriers used by the CPE for initial ranging

N_{sub} is 1680 for PHY mode 1 or 840 for PHY mode 2

The CPE shall send a CDMA code with a power level resulting in the $EIRP_{IR\_CPE}$ per subcarrier. If the CPE does not receive a response after waiting at least one frame to allow processing at the MR-BS, the CPE shall send a new CDMA code at the next appropriate Initial Ranging transmission opportunity with 1 dB higher power level. The CPE shall, however, stop increasing the power level at the following condition:

$$EIRP_{IR\_MAX} + 10\times\log(N_{IR\_sub}) > EIRP_{CPE\_MAX}$$

where

$EIRP_{CPE\_MAX}$ is the upper bound in maximum transmitted EIRP for the CPE on the current operating channel as described in Table 108 of 7.7.11.3.2.1 or 4 Watt for the fixed CPE whichever is the smallest

$EIRP_{IR\_CPE\_MAX}$ is the upper bound for the increased $EIRP_{IR\_CPE}$

If the CPE receives a RNG-CMD message containing the parameters of the code it has transmitted and the status "continue," it shall consider the transmission attempt unsuccessful but implement the corrections specified in the RNG-CMD and issue another CDMA code after the appropriate backoff delay. If the CPE receives an US-MAP containing a CDMA allocation IE with the parameters of the code it has transmitted, it shall consider the RNG-CMD reception successful, and proceed to send a unicast RNG-REQ (on Initial Ranging FID, allocated to Cell SID) on the allocated BW.

Once the MR-BS has successfully received the RNG-REQ message, it shall return a RNG-CMD message using the initial ranging connection (see 12.2). Within the RNG-CMD message shall be the Station ID (SID) assigned to this CPE. The message shall also contain information on the required CPE EIRP level, offset frequency adjustment as well as the proper timing advance when needed. At this point the MR-BS shall start using invited Initial Ranging Intervals addressed to the CPE's Basic FID to complete the ranging process, unless the status of the RNG-CMD message is "success," in which case the initial ranging procedure shall end.

If the status of the RNG-CMD message is "continue," the CPE shall wait for an individual Initial Ranging Interval assigned to its Basic FID. Using this interval, the CPE shall transmit another RNG-REQ message using the Basic FID along with any power level and timing offset corrections.

The MR-BS shall return another RNG-CMD message to the CPE with any additional fine-tuning required. The ranging request/response steps shall be repeated until the response contains a "Ranging Successful" notification or the MR-BS aborts ranging. Once successfully ranged (timing, frequency and EIRP are within tolerance at the MR-BS), the CPE shall join normal data traffic in the upstream. In particular, the retry counts and timer values for the ranging process are defined in Table 273.

On receiving a RNG-CMD instruction to move to a new channel during initial ranging, the CPE shall obtain a new SID via initial ranging and registration.

It is possible that the RNG-CMD may be lost after transmission by the MR-BS. The CPE shall recover by timing out and reissuing its Initial RNG-REQ. Since the CPE is uniquely identified by the source MAC address in the Ranging Request, the MR-BS may immediately reuse the SID previously assigned. If the MR-BS assigns a new SID, it shall immediately age out the old SID and associated CPE.

7.14.3.8.2 CDMA initial ranging and automatic adjustments to a distributed scheduling R-CPE

A CPE shall synchronize to the local frame preamble within a distributed relay zone (DRZ) in order to perform initial ranging to the distributed scheduling R-CPE. At this point, the CPE shall scan the US-MAP message to find a DRZ Initial Ranging Interval within a local cell managed by a distributed scheduling R-CPE. The distributed scheduling R-CPE may allocate a DRZ Initial Ranging Interval consisting of one or more transmission opportunities in a DRZ for upstream. The CPE shall extract the number of DRZ initial ranging codes (see Table 31, element ID 157) from the UCD MAC management message.

The CPE randomly selects the CDMA code as described in 7.15.2.1a and sends the DRZ initial ranging CDMA code on the DRZ of US allocation dedicated for that purpose. The distributed scheduling R-CPE receives the CDMA code. As many CPEs may contend for ranging, the CDMA code received may be the sum of many CPE transmissions. The distributed scheduling R-CPE isolates each of these transmissions and computes the ranging adjustments based on the relative time of arrival of each CPE upstream burst, i.e., the timing offset, so that all these bursts arrive at the distributed scheduling R-CPE at the beginning of the symbol period within sufficient tolerance.

Ranging adjusts each CPE's timing offset such that each CPE appears to be co-located with the distributed scheduling R-CPE. The CPE shall set its initial timing offset to "zero advance" as if it was physically co-located with the distributed scheduling R-CPE. When the DRZ Initial Ranging transmission opportunity occurs, the CPE shall send a CDMA code. After reception and decoding of this CDMA code, the distributed scheduling R-CPE will react by sending a RNG-CMD MAC message in a following frame with the same CDMA code and indicate the timing advance that the CPE should use for its upstream transmissions (see Table 44) so that the beginning of its bursts is aligned with the center of the cyclic prefix within the tolerance indicated in 9.9.1.

When the DRZ Initial Ranging transmission opportunity occurs, the CPE shall send a DRZ initial ranging CDMA code. Thus, the CPE sends the message as if it were co-located with the distributed scheduling R-CPE.

The CPE shall calculate the transmit EIRP per subcarrier for initial ranging, $EIRP_{IR\_CPE}$, from the following equation:

$$EIRP_{IR\_CPE} = EIRP_{R\text{-}CPE} + RSS_{IR\_R\text{-}CPE\_nom} - (RSS_{IR\_CPE} - G_{RX\_CPE}) + 10\times\log(N_{IR\_sub}/N_{sub})$$

where

$RSS_{IR\_R\text{-}CPE\_nom}$ and $EIRP_{R\text{-}CPE}$ are defined in a DCD IE (see Table 23)

G_{RX_CPE} is the antenna gain at the CPE

RSS_{IR_CPE} is the RSSL measured by the CPE, which is then corrected by the CPE antenna gain to represent the RSSL for an isotropic antenna

N_{IR_sub} is the number of subcarriers used by the CPE for initial ranging

N_{sub} is 1680 for PHY mode 1 or 840 for PHY mode 2

The CPE shall send a CDMA code with a power level resulting in the $EIRP_{IR\_CPE}$ per subcarrier. If the CPE does not receive a response after waiting at least one frame to allow processing at the distributed scheduling R-CPE, the CPE shall send a new CDMA code at the next appropriate Initial Ranging transmission opportunity with 1 dB higher power level. The CPE shall, however, stop increasing the power level at the following condition:

$$EIRP_{IR\_MAX} + 10\times\log(N_{IR\_sub}) > EIRP_{CPE\_MAX}$$

where

$EIRP_{CPE\_MAX}$ is the upper bound in maximum transmitted EIRP for the CPE on the current operating channel as described in Table 108 of 7.7.11.3.2.1 or 4 Watt for the fixed CPE whichever is the smallest

$EIRP_{IR\_CPE\_MAX}$ is the upper bound for the increased $EIRP_{IR\_CPE}$

If the CPE receives a RNG-CMD message containing the parameters of the code it has transmitted and the status "continue," it shall consider the transmission attempt unsuccessful but implement the corrections specified in the RNG-CMD and issue another CDMA code after the appropriate backoff delay. If the CPE receives an US-MAP containing a CDMA allocation IE with the parameters of the code it has transmitted, it shall consider the RNG-CMD reception successful, and proceed to send a unicast RNG-REQ (on Initial Ranging FID, allocated to Cell SID) on the allocated BW.

Once the distributed scheduling R-CPE has successfully received the RNG-REQ message, it shall return a RNG-CMD message using the initial ranging connection (see 12.2). Within the RNG-CMD message it shall be the Station ID, which is selected into one of the Local SID Group (7.7.7.3.6), assigned to this CPE. Note that a distributed scheduling R-CPE shall obtain the Local SID Group (7.7.7.3.6) used in a local cell from the MR-BS at registration. The RNG-CMD message shall also contain information on the required CPE EIRP level, offset frequency adjustment as well as the proper timing advance when needed. At this point the distributed scheduling R-CPE shall start using DRZ invited Initial Ranging Intervals addressed to the CPE's Basic FID to complete the ranging process, unless the status of the RNG-CMD message is "success," in which case the initial ranging procedure shall end.

If the status of the RNG-CMD message is “continue,” the CPE shall wait for a DRZ individual Initial Ranging Interval assigned to its Basic FID. Using this interval, the CPE shall transmit another RNG-REQ message using the Basic FID along with any power level and timing offset corrections.

The distributed scheduling R-CPE shall return another RNG-CMD message to the CPE with any additional fine-tuning required. The ranging request/response steps shall be repeated until the response contains a “Ranging Successful” notification or the R-CPE aborts ranging. Once successfully ranged (timing, frequency and EIRP are within tolerance at the R-CPE), the CPE shall join normal data traffic in the upstream. In particular, the retry counts and timer values for the ranging process are defined in Table 273.

On receiving a RNG-CMD instruction to move to a new channel during initial ranging, the CPE shall obtain a new SID via initial ranging and registration.

It is possible that the RNG-CMD may be lost after transmission by the distributed scheduling R-CPE. The CPE shall recover by timing out and reissuing its Initial RNG-REQ. Since the CPE is uniquely identified by the source MAC address in the Ranging Request, the distributed scheduling R-CPE may immediately reuse the SID previously assigned. If the distributed scheduling R-CPE assigns a new SID, it shall immediately age out the old SID and associated CPE.

7.14.3.8.3 CDMA initial ranging and automatic adjustments by relaying on centralized scheduling R-CPE

Although a CPE successfully obtains downstream parameters from a MR-BS, CDMA initial ranging to the MR-BS as described in 7.14.3.8.1 may be failed due to the CPE transmitting power constraint. However, a CPE is still able to have an uplink to MR-BS by relaying on a centralized scheduling R-CPE. A CPE shall synchronize to the frame preamble in order to perform initial ranging to a MR-BS. At this point, the CPE shall scan the US-MAP message to find an Initial Ranging Interval and CRZ Initial Ranging Interval if available. The MR-BS may allocate a CRZ Initial Ranging Interval consisting of one or more transmission opportunities within a CRZ of US subframe. The CPE shall extract the number of initial ranging codes and may extract the number of CRZ initial ranging codes (see Table 31, element ID 155) from the UCD MAC management message.

The CPE randomly selects the CDMA code as described in 7.15.2.1a and sends the initial ranging CDMA code to the MR-BS on the Initial Ranging Interval, and sends the CRZ initial ranging CDMA code to the centralized scheduling R-CPE on the CRZ Initial Ranging Interval as well in US allocation dedicated for that purpose. The initial ranging between the CPE and the MR-BS shall be following as described in 7.14.3.8.1. The following section describes the case that the CRZ initial ranging between the CPE and the centralized scheduling R-CPE.

The centralized scheduling R-CPE may receive the CRZ Initial Ranging CDMA code within the CRZ Initial Ranging Interval in a CRZ of US subframe. As many CPEs may contend for ranging, the CDMA code received may be the sum of many CPE transmissions. The centralized scheduling R-CPE isolates each of these transmissions and computes the ranging adjustments based on the relative time of arrival of each CPE upstream burst, i.e., the timing offset, so that all these bursts arrive at the centralized scheduling R-CPE at the beginning of the symbol period within sufficient tolerance.

Ranging adjusts each CPE’s timing offset such that each CPE appears to be co-located with the centralized scheduling R-CPE. The CPE shall set its initial timing offset to “zero advance” as if it was physically co-located with the centralized scheduling R-CPE. When the CRZ Initial Ranging transmission opportunity occurs, the CPE may send a CRZ CDMA code. After reception and decoding of this CDMA code, the centralized scheduling R-CPE will react by sending a RNG-CMD MAC message in a following frame with the same CDMA code and indicate the timing advance that the CPE should use for its upstream transmissions (see Table44) so that the beginning of its bursts is aligned with the center of the cyclic prefix within the tolerance indicated in 9.9.1. For the transmission of RNG-CMD to the CPE, a centralized scheduling R-CPE shall request bandwidth to a MR-BS by using an Extended Bandwidth Request Subheader (7.6.1.2.1a).

When the CPE receives the RNG-CMD MAC message, CRZ initial ranging will start for the centralized scheduling CPE. The CPE randomly selects the CDMA code as described in 7.15.2.1a and sends the CRZ initial ranging CDMA code to the centralized scheduling R-CPE on the CRZ Initial Ranging Interval. Thus, the CPE sends the message as if it were co-located with the centralized scheduling R-CPE.

The CPE shall calculate the transmit EIRP per subcarrier for initial ranging, $EIRP_{IR\_CPE}$, from the following equation:

$$EIRP_{IR\_CPE} = EIRP_{R\text{-}CPE} + RSS_{IR\_R\text{-}CPE\_nom} - (RSS_{IR\_CPE} - G_{RX\_CPE}) + 10\times\log(N_{IR\_sub}/N_{sub})$$

where

$RSS_{IR\_R\text{-}CPE\_nom}$ and $EIRP_{R\text{-}CPE}$ are defined in a DCD IE (see Table 23x)

G_{RX_CPE} is the antenna gain at the CPE

RSS_{IR_CPE} is the RSSL measured by the CPE, which is then corrected by the CPE antenna gain to represent the RSSL for an isotropic antenna

N_{IR_sub} is the number of subcarriers used by the CPE for initial ranging

N_{sub} is 1680 for PHY mode 1 or 840 for PHY mode 2

The CPE shall send a CDMA code with a power level resulting in the $EIRP_{IR\_CPE}$ per subcarrier. If the CPE does not receive a response after waiting at least one frame to allow processing at the centralized scheduling R-CPE, the CPE shall send a new CDMA code at the next appropriate Initial Ranging transmission opportunity with 1 dB higher power level. The CPE shall, however, stop increasing the power level at the following condition:

$$EIRP_{IR\_MAX} + 10\times\log(N_{IR\_sub}) > EIRP_{CPE\_MAX}$$

where

$EIRP_{CPE\_MAX}$ is the upper bound in maximum transmitted EIRP for the CPE on the current operating channel as described in Table 108 of 7.7.11.3.2.1 or 4 Watt for the fixed CPE whichever is the smallest

$EIRP_{IR\_CPE\_MAX}$ is the upper bound for the increased $EIRP_{IR\_CPE}$

If the CPE receives a RNG-CMD message containing the parameters of the code it has transmitted and the status “continue,” it shall consider the transmission attempt unsuccessful but implement the corrections specified in the RNG-CMD and issue another CDMA code after the appropriate backoff delay. If the CPE receives a RNG-CMD message containing the parameters of the code it has transmitted and the status “success”, it shall proceed to send a unicast RNG-REQ (on Initial Ranging FID, allocated to Cell SID) to the centralized scheduling R-CPE on the allocated BW, which shall be required by the centralized scheduling R-CPE to the MR-BS by using the Extended Bandwidth Request Subheader (7.6.1.2.1a). If the centralized scheduling R-CPE receives RNG-REQ from the CPE, the centralized scheduling R-CPE relays the RNG-REQ messages, which will be conveyed on a Container message (7.7.26), to the MR-BS. The container message may contain several management messages, which are scheduled to transmit from a centralized scheduling R-CPE to the MR-BS.

Once the MR-BS has successfully received the RNG-REQ message by encoding the received Container message it shall return a Container ACK message (7.7.26.1) with a confirmation code for the received messages to the centralized scheduling R-CPE. If the confirmation code for a certain management message is not “success”, the centralized scheduling R-CPE shall retransmit the indicated management message to the MR-BS. After correctly receiving RNG-REQ, the MR-BS shall return a RNG-CMD message to the CPE. Within the RNG-CMD message shall be the Station ID (SID) assigned to this CPE.

Moreover, a CPE can successfully perform CDMA initial ranging to the several devices including a MR-BS and centralized scheduling R-CPEs. In this case, the CPE shall select one of those.

7.14.3.8.4 Ranging parameter adjustment

Adjustment of local parameters (e.g., transmit EIRP) in a CPE as a result of the receipt or non-receipt of a RNG-CMD message is considered to be implementation-dependent with the following restrictions:

a) All parameters shall be within the approved range at all times.

b) EIRP adjustment shall start from the initial value selected with the algorithm described in 7.14.3.8.1, 7.14.3.7.2, or 7.14.3.7.3 unless a valid EIRP setting is available from non-volatile storage, in which case this value may be used a the starting point.

c) EIRP adjustment shall be capable of being reduced or increased by the specified amount in response to the RNG-CMD messages.

d) If, during initialization, EIRP is increased to the maximum value as determined in 7.14.3.8.1, 7.14.3.7.2, or 7.14.3.7.3 without a response from the MR-BS, it shall go back to the minimum EIRP and ramp up to its maximum EIRP four (4) times before aborting the ranging process with this base station.

On receiving a RNG-CMD message, the CPE shall not transmit until the RF signal has been adjusted in accordance with the RNG-CMD and has stabilized.

7.14.3.9 CPE transmit basic capabilities

7.14.3.9.1 CPE transmit basic capabilities to an MR-BS

Immediately following the completion of initial ranging to the MR-BS, the CPE informs the MR-BS of its basic capabilities by transmitting a CBC-REQ message (see Table 105) with its capabilities set to “on” (see Figure 39). Note that T18 is a timer used to wait for CBC-RSP timeout and the default value is indicated in Table 272.

The MR-BS responds with a CBC-RSP message (see Table 106) with the intersection of the CPE’s and MR-BS’s capabilities set to “on” (see Figure 40 and Figure 41, respectively). The timer T9 refers to the time allowed between the MR-BS sending a RNG-CMD to a CPE, and receiving a CBC-REQ from that same CPE, and the minimum value is specified in Table 272. Note that the CPE capability information is presented in 7.7.7.3.4. When T9 expires, the SID assigned during ranging shall be aged out and the CPE shall have to attempt ranging process over again while not exceeding the maximum number of CDMA ranging retries indicated in Table 273.

7.14.3.9.2 CPE transmit basic capabilities to distributed scheduling R-CPE

Immediately following the completion of DRZ initial ranging, the CPE informs the distraibuted scheduling R-CPE of its basic capabilities by transmitting a CBC-REQ message (see Table 105) with its capabilities set to “on” (see Figure 39). Note that T18 is a timer used to wait for CBC-RSP timeout and the default value is indicated in Table 272.

The distributed scheduling R-CPE responds with a CBC-RSP message (see Table 106) with the intersection of the CPE’s and distributed scheduling R-CPE’s capabilities set to “on” (see Figure 40 and Figure S1, respectively). The timer T9 refers to the time allowed between the distributed scheduling R-CPE sending a RNG-CMD to a CPE, and receiving a CBC-REQ from that same CPE, and the minimum value is specified in Table 272. Note that the CPE capability information is presented in 7.7.7.3.4. When T9 expires, the SID assigned during ranging shall be aged out and the CPE shall have to attempt ranging process over again while not exceeding the maximum number of CDMA ranging retries indicated in Table 273.

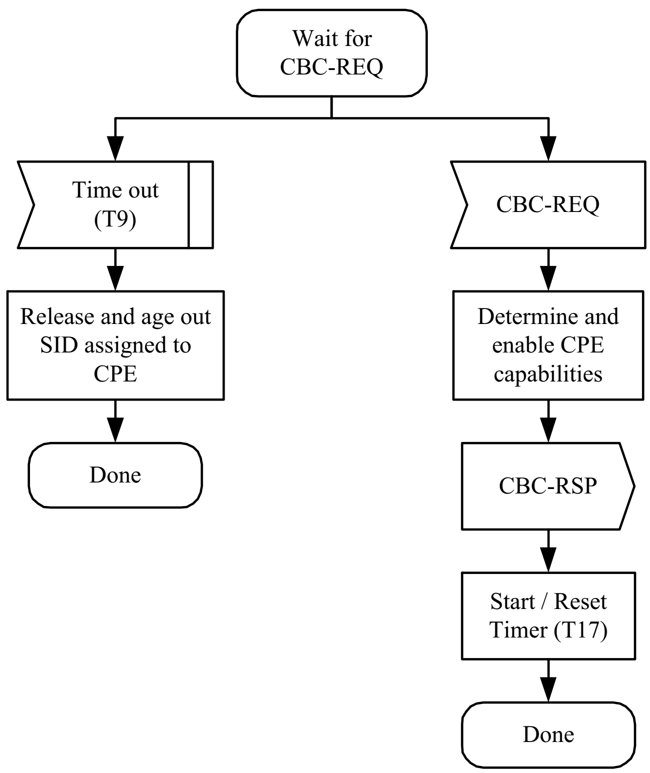

Figure S1—Negotiate basic capabilities at distributed scheduling R-CPE

7.14.3.9.3 CPE transmit basic capabilities relaying on a centralized scheduling R-CPE

Immediately following the completion of CRZ initial ranging, the CPE informs the centralized scheduling R-CPE of its basic capabilities by transmitting a CBC-REQ message (see Table 105) with its capabilities set to “on” (see Figure 39). Note that T18 is a timer used to wait for CBC-RSP timeout and the default value is indicated in Table 272. When the centralized scheduling R-CPE receives the CBC-REQ messages from the CPEs, the centralized scheduling R-CPE transmits a Container message (7.7.26) containing the received CBC-REQ messages to the MR-BS (see Figure T1). Note that the Container messages may contain not only CBC-REQ messages but also other management messages. Note that Txx is a timer used to wait for Container ACK timeout, which is indicated in Table 272.

When the MR-BS has successfully received the CBC-REQ message by encoding the received Container message, it shall return a Container ACK message (7.7.26.1) with a confirmation code for the CBC-REQ to the centralized scheduling R-CPE. If the confirmation code for a certain management message is not “success”, the centralized scheduling R-CPE shall retransmit the indicated management message to the MR-BS (see Figure U1). After correctly receiving CBC-REQ, the MR-BS responds with a CBC-RSP message (see Table 106) to the CPE, with the intersection of the CPE’s and MR-BS’s capabilities set to “on”. The timer T9 refers to the time allowed between the MR-BS sending a RNG-CMD to a CPE, and receiving a CBC-REQ from that same CPE, and the minimum value is specified in Table 272. Note that the CPE capability information is presented in 7.7.7.3.4. When T9 expires, the SID assigned during ranging shall be aged out and the CPE shall have to attempt ranging process over again while not exceeding the maximum number of CDMA ranging retries indicated in Table 273.

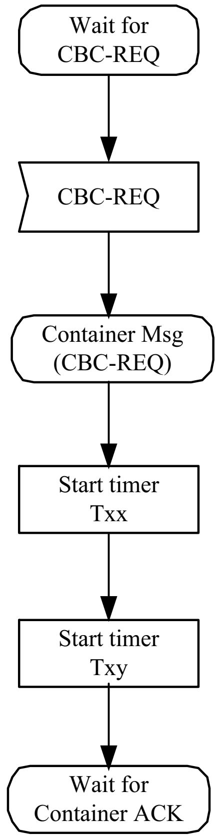

Figure T1—Wait for CBC-REQ and Sending container message including CBC-REQ at a centralized scheduling R-CPE

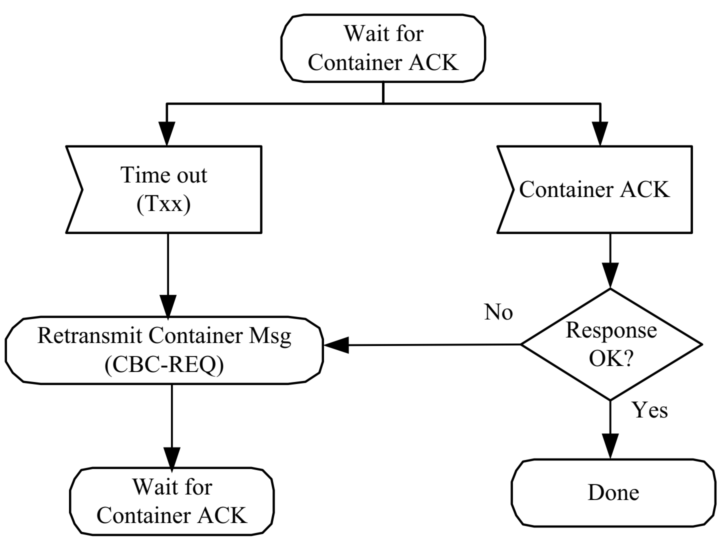

Figure U1—Wait for Container ACK at a centralized scheduling R-CPE

7.14.3.10 CPE authentication and key exchange

7.14.3.11 Registration

7.14.3.11.1 Registration to MR-BS

Registration is the process by which the CPE verifies its configuration with the MR-BS. If the CPE supports a configuration that is set by the MR-BS, it is allowed entry into the network and thus becomes manageable. To register with a MR-BS, the CPE shall send a REG-REQ message to the MR-BS. The REG-REQ message shall include a CPE NMEA Location string IE except for Mode I CPE.

During registration, the CPE's NMEA Location String and various operational parameters are configured (see 7.7.7.3). The CPE sends its location data string (see 7.6.1.3.1.6) upon initial registration and re-registration. When the IP Address Allocation Information Element (see 7.7.7.3.4.11) is present in the REG-REQ message, the MR-BS shall include this IP address allocation parameter in the REG-RSP message to command the CPE to use the indicated version of IP on the secondary management connection. The MR-BS shall command the use of exactly one of the IP versions supported by the CPE.

The MR-BS shall determine the location of the antenna of each associated CPE with the accuracy as specified in Table A.9 for the specific regulatory domain. The MR-BS's SM shall receive the generated NMEA string and validate its contents.

The MR-BS's SM shall provide the geolocation data to the database service. The MR-BS shall refuse to serve the CPE if

— The geographic location of the CPE except for Mode I CPE has not been successfully determined as indicated by a failed validation of the data in the NMEA string. Validation shall fail if
  a) the NMEA string contains data that is outside the allowable range of values or;
  b) the distance between the initializing CPE and the MR-BS or other associated CPEs is outside the allowable range of values.
— The database service has indicated that the CPE except for Mode I CPE cannot operate on the channel on which the WRAN network intends to operate.

In the first case, validation of the NMEA string fails and CPE initialization fails, in the second case, the CPE initialization fails on the current channel and shall proceed to the next channel on its available WRAN services list.

The MR-BS shall respond with a REG-RSP message. The REG-RSP message shall include the Permanent Station ID (see Table 61), if CPE Privacy (see 8.7) is enabled. Figure 42 shows the procedure that shall be followed by the CPE to initiate registration.

Once the CPE has sent a REG-REQ to the MR-BS, it shall wait for a REG-RSP to authorize it to forward traffic to the network. Figure 43 shows the waiting procedure that shall be followed by the CPE.

From encoding CPE operation capabilities in the REG-RSP (7.7.7.3.4.13), the CPE will operate as one of operating modes: a fixed subscriber CPE, a portable subscriber CPE (Mode I), a centralized scheduling R-CPE, or a distributed scheduling R-CPE (fixed or portable Mode II).

The MR-BS shall perform the operations shown in Figure 44. Note that the Timer T13 represents the time allowed for a CPE, following receipt of a REG-RSP message, to send a TFTP-CPLT message to the MR-BS, and its minimum time is specified in Table 272. In addition, the Timer T28 is the time allowed for the MR-BS to complete the transmission of channel sets; its default value is specified in Table 272.

WRAN CPEs and MR-WRAN CPEs are managed devices. Network entry is not considered complete until after the TFTP- CPLT/RSP (see 7.7.19). When the MR-BS and CPE complete the TFTP-CPLT/RSP exchange, timer T30 is scheduled for the value set in CPE Registration Timer (7.7.7.3.5) IE. When T30 expires the MR-BS and CPE shall delete all information pertaining to their associations (e.g., SIDs, registered capabilities, active service-flow parameters, remaining security context), regardless of whether or not the CPE is currently being served by the MR-BS.

Prior to expiration of T30, the MR-BS may attempt to verify connectivity to a CPE via periodic ranging. This can be facilitated by the MR-BS sending an unsolicited RNG-CMD message with Ranging Status field set to "Re-range & Re-register" (see Table 44). Upon receiving said RNG-CMD, the CPE shall attempt to re-range with the MR-BS, as well as send a REG-REQ with the current configuration of the CPE NMEA Location String IE (7.6.1.3.1.6) and Manufacturer-specific Antenna Model IE (7.7.7.3.4.8) to inform the MR-BS of its current position and antenna information. Upon sending this REG-REQ to the MR-BS, the CPE should use the signaling in 9.12.2 to re-populate the MIBs used to configure these IEs (see *wranIfCpeAntennaGainTable* and *wranIfAntennaModel* in 13.1) and update the configuration of these IEs by reading the information. If the CPE finds out that this information has changed, it shall re-initialize itself. If the MR-BS does not receive either the RNG-REQ or the REG-REQ (with the location information) from the CPE in the allocated opportunity, the MR-BS shall wait until T30 expires before de-registering the CPE.

If the CPE is currently being served by the MR-BS, the MR-BS can force the CPE to delete the pertinent information before expiration of T30 by the following:

a) Send a DREG-CMD to CPE with Action Code = 0x04 (see Table 115) to shutdown the CPE. This is done if the MR-BS detects that the CPE has moved outside the current coverage area of the MR-BS and is not able to service it.

b) Send a DREG-CMD to CPE with Action Code = 0x05 (see Table 115) to force CPE to reinitialize on the current operating channel. This is done if the CPE's movement is beyond the movement threshold of ±25 m (see policy 8 in Table 234), but the CPE's movement does not result in a new backup/candidate channel list upon query of the database service.

c) Send a DREG-CMD to the CPE with Action Code = 0x01 and subsequently another DREG-CMD with Action Code = 0x03 (see Table 115) to temporarily disable the CPE's transmission. This is done, to temporarily disable the CPE's transmission when a CPE's movement is within the movement threshold of ±25 m (see Policy 8 in Table 234), but the CPE's movement does not results in a new backup/candidate channel list upon query of the database service. This avoids having to reinitialize the CPE.

For case a), T30 shall be cleared when the CPE is shutdown. For case b), the T30 shall be reset upon completion of re-registration. For case c), the T30 shall be reset upon sending the DREG-CMD to re-enable CPE.

If the SM (upon interrogating the SSA) detected that the CPE has moved, the MR-BS shall request de-registration by sending a DREG-CMD message to the CPE set with the appropriate Action Code as mentioned above.

7.14.3.11.2 Registration to a distributed scheduling R-CPE

To register with a distributed scheduling R-CPE, the CPE shall send a REG-REQ message to the distributed scheduling R-CPE. The REG-REQ message may include a CPE NMEA Location string IE.

During registration, the various operational parameters are configured (see 7.7.7.3). When the IP Address Allocation Information Element (see 7.7.7.3.4.11) is present in the REG-REQ message, the distributed scheduling R-CPE shall include this IP address allocation parameter in the REG-RSP message to command the CPE to use the indicated version of IP on the secondary management connection. The distributed scheduling R-CPE shall command the use of exactly one of the IP versions supported by the CPE.

The distributed scheduling R-CPE may determine the location of the antenna of each associated CPE with the accuracy as specified in Table A.9 for the specific regulatory domain. The distributed scheduling R-CPE's SM shall receive the validate its contents.

The distributed scheduling R-CPE's SM may provide the geolocation data of the CPE to the MR-BS. The MR-BS may refuse to serve the CPE if the geographic location of the CPE has not been successfully determined as indicated by a failed validation of the data in the NMEA string. Validation shall fail if

a) The NMEA string contains data that is outside the allowable range of values or;

b) The distance between the initializing CPE and the associated distributed scheduling R-CPEs is outside the allowable range of values.

When a distributed scheduling R-CPE receives a REG-REQ message from the CPE, the distributed scheduling R-CPE sends a Container message (7.7.26) containing the received REG-REQ message to the MR-BS. When the MR-BS has successfully received the REG-REQ message by encoding the received Container message, it shall return a Container ACK message (7.7.26.1) with a confirmation code for the REG-REQ to the distributed scheduling R-CPE. If the confirmation code for a certain management message is not "success", the distributed scheduling R-CPE shall retransmit the indicated management message to the MR-BS. After correctly receiving REG-REQ, the MR-BS responds with a REG-RSP message (see Table 106) to the CPE. The REG-RSP message shall include the Permanent Station ID (see Table 61), if CPE Privacy (see 8.7) is enabled. Figure V1 shows the procedure that shall be followed by the CPE to initiate registration.

Once the CPE has sent a REG-REQ to the distributed scheduling R-CPE, it shall wait for a REG-RSP to authorize it to forward traffic to the local network. Figure W1 shows the waiting procedure that shall be followed by the CPE.

The distributed scheduling R-CPE shall perform the operations shown in Figure X1. Note that the Timer T13 represents the time allowed for a CPE, following receipt of a REG-RSP message, to send a TFTP-CPLT message to the distributed scheduling R-CPE, and its minimum time is specified in Table 272. In addition, the Timer T28 is the time allowed for the MR-BS to complete the transmission of channel sets; its default value is specified in Table 272.

IEEE 802.22b CPEs are managed devices. Network entry is not considered complete until after the TFTP-CPLT/RSP (see 7.7.19). When the MR-BS and CPE through the distributed scheduling R-CPE complete the TFTP-CPLT/RSP exchange, timer T30 is scheduled for the value set in CPE Registration Timer (7.7.7.3.5) IE. When T30 expires the MR-BS, distributed scheduling R-CPE and CPE shall delete all information pertaining to their associations (e.g., SIDs, registered capabilities, active service-flow parameters, remaining security context), regardless of whether or not the CPE is currently being served by the distributed scheduling R-CPE.

Prior to expiration of T30, the distributed scheduling R-CPE may attempt to verify connectivity to a CPE via periodic ranging. This can be facilitated by the distributed scheduling R-CPE sending an unsolicited RNG-CMD message with Ranging Status field set to "Re-range & Re-register" (see Table 44). Upon receiving said RNG-CMD, the CPE shall attempt to re-range with the distributed scheduling R-CPE, as well as send a REG-REQ to the distributed scheduling R-CPE. The distributed scheduling R-CPE shall send a Container message containing the received REG-REQ message to the MR-BS. If the distributed scheduling R-CPE does not receive either the RNG-REQ or the REG-REQ (with the location information) from the CPE in the allocated opportunity, the distributed scheduling R-CPE shall wait until T30 expires before de-registering the CPE.

If the CPE is currently being served by the distributed scheduling R-CPE, the distributed scheduling R-CPE can force the CPE to delete the pertinent information before expiration of T30 by the following:

Send a DREG-CMD to CPE with Action Code = 0x04 (see Table 115) to shutdown the CPE. This is done if the distributed scheduling R-CPE detects that the CPE has moved outside the current coverage area of the R-CPE and is not able to service it.

a) Send a DREG-CMD to CPE with Action Code = 0x05 (see Table 115) to force CPE to reinitialize on the current operating channel. This is done if the CPE's movement is beyond the movement threshold of ±25 m (see policy 8 in Table 234), but the CPE's movement does not result in a new backup/candidate channel list upon query of the database service.

b) Send a DREG-CMD to the CPE with Action Code = 0x01 and subsequently another DREG-CMD with Action Code = 0x03 (see Table 115) to temporarily disable the CPE's transmission. This is done, to temporarily disable the CPE's transmission when a CPE's movement is within the movement threshold of ±25 m (see Policy 8 in Table 234), but the CPE's movement does not results in a new backup/candidate channel list upon query of the database service. This avoids having to reinitialize the CPE.

c) For case a), T30 shall be cleared when the CPE is shutdown. For case b), the T30 shall be reset upon completion of re-registration. For case c), the T30 shall be reset upon sending the DREG-CMD to re-enable CPE.

If the SM (upon interrogating the SSA) detected that the CPE has moved, the distributed scheduling R-CPE shall request de-registration by sending a DREG-CMD message to the CPE set with the appropriate Action Code as mentioned above.

After the distributed scheduling R-CPE de-registers the CPE, the distributed scheduling R-CPE shall send Local Cell Update message (7.7.25) to the MR-BS as shown in Figure Y1. When the MR-BS receives Local Cell Update request message from the distributed scheduling R-CPE, the MR-BS shall update registration information of CPEs indicated in the message (see Figure AA1), and send Local Cell Update response to the distributed scheduling R-CPE as shown in Figure Z1.

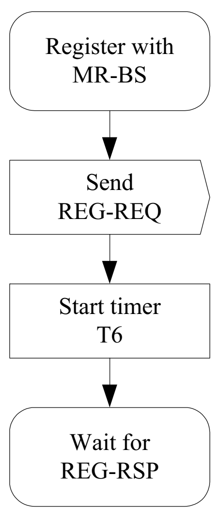

Figure V1—CPE registration in a local cell

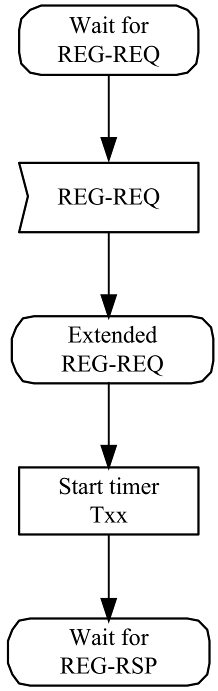

Figure W1—Wait for REG-REQ and Sending Extended REG-REQ at a distributed scheduling R-CPE

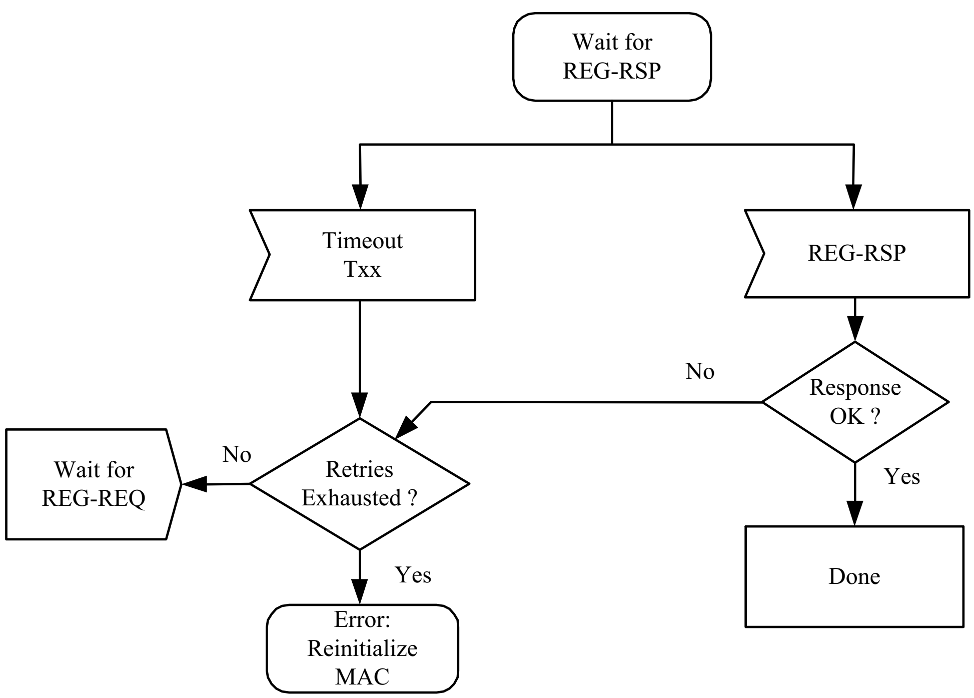

Figure X1—Wait for REG-RSP at a distributed scheduling R-CPE

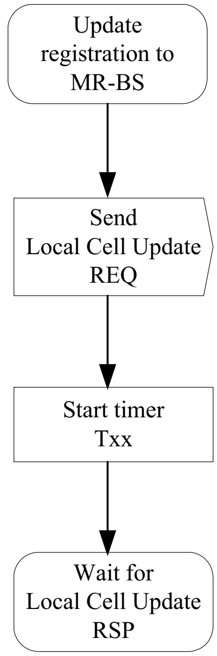

Figure Y1—Sending Local Cell Update REQ from a distributed scheduling R-CPE

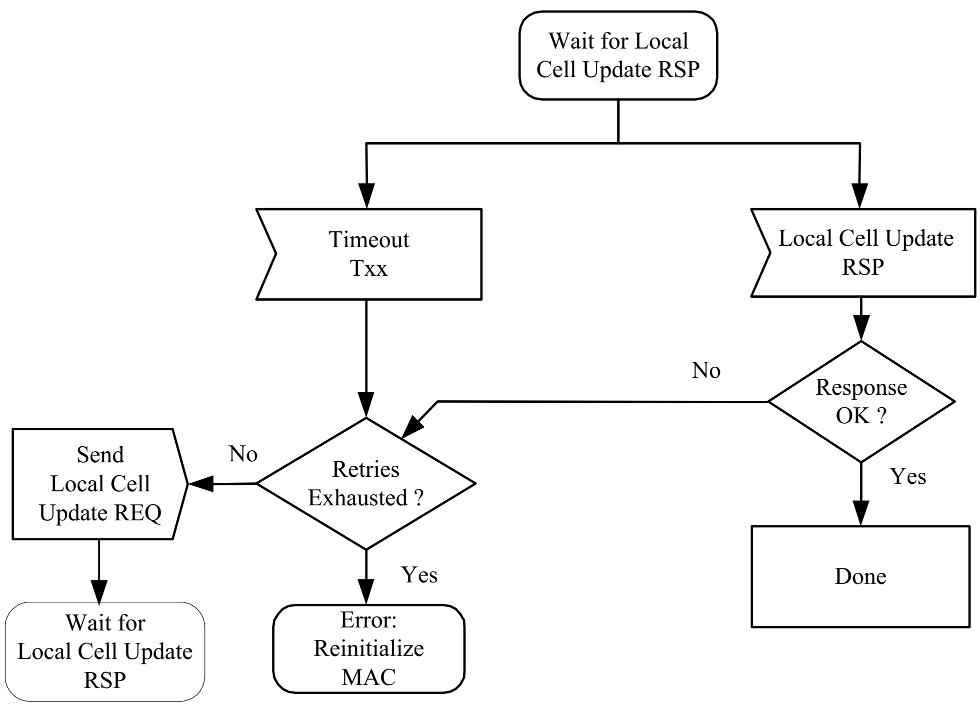

Figure Z1—Wait for Local Cell Update RSP at a distributed scheduling R-CPE

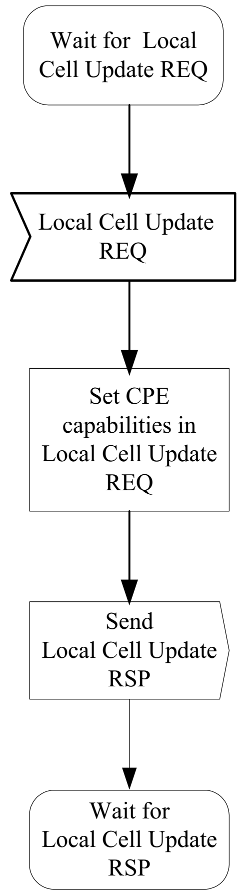

Figure AA1—Local cell update at MR-BS

7.14.3.11.3 Registration to an MR-BS via a centralized scheduling R-CPE

To register with a MR-BS by relaying on a centralized scheduling R-CPE, the CPE shall send a REG-REQ message to the the centralized scheduling R-CPE. The REG-REQ message may include a CPE NMEA Location string IE. The centralized scheduling R-CPE shall send a Container message (7.7.26) including the REQ-REQ message to the MR-BS. When the MR-BS has successfully received the REG-REQ message by encoding the received Container message, it shall return a Container ACK message (7.7.26.1) with a confirmation code for the REG-REQ to the centralized scheduling R-CPE. If the confirmation code for a certain management message is not "success", the centralized scheduling R-CPE shall retransmit the indicated management message to the MR-BS.

During registration, the CPE's NMEA Location String and various operational parameters are configured (see 7.7.7.3). The CPE sends its location data string (see 7.6.1.3.1.6) upon initial registration and re-registration. When the IP Address Allocation Information Element (see 7.7.7.3.4.11) is present in the REG-REQ message, the MR-BS shall include this IP address allocation parameter in the REG-RSP message to command the CPE to use the indicated version of IP on the secondary management connection. The MR-BS shall command the use of exactly one of the IP versions supported by the CPE.

The MR-BS shall respond with a REG-RSP message. The REG-RSP message shall include the Permanent Station ID (see Table 61), if CPE Privacy (see 8.7) is enabled. Figure AB1 shows the procedure that shall be followed by the CPE to initiate registration.

Once the CPE has sent a REG-REQ to the MR-BS, it shall wait for a REG-RSP to authorize it to forward traffic to the network. Figure AC1 shows the waiting procedure that shall be followed by the CPE.

The MR-BS shall perform the operations shown in Figure 44. Note that the Timer T13 represents the time allowed for a CPE, following receipt of a REG-RSP message, to send a TFTP-CPLT message to the MR-BS, and its minimum time is specified in Table 272. In addition, the Timer T28 is the time allowed for the MR-BS to complete the transmission of channel sets; its default value is specified in Table 272.

IEEE 802.22b CPEs are managed devices. Network entry is not considered complete until after the TFTP-CPLT/RSP (see 7.7.19). When the MR-BS and CPE complete the TFTP-CPLT/RSP exchange, timer T30 is scheduled for the value set in CPE Registration Timer (7.7.7.3.5) IE. When T30 expires the MR-BS and CPE shall delete all information pertaining to their associations (e.g., SIDs, registered capabilities, active service-flow parameters, remaining security context), regardless of whether or not the CPE is currently being served by the MR-BS.

Prior to expiration of T30, the MR-BS may attempt to verify connectivity to a CPE via periodic ranging. This can be facilitated by the MR-BS sending an unsolicited RNG-CMD message with Ranging Status field set to “Re-range & Re-register” (see Table 44). Upon receiving said RNG-CMD, the CPE shall attempt to re-range with the centralized scheduling R-CPE, as well as send a REG-REQ to the centralized scheduling R-CPE. The centralized scheduling R-CPE sends a Container message containing the received REG-REQ message to the MR-BS. Upon sending this REG-REQ to the MR-BS, the CPE should use the signaling in 9.12.2 to re-populate the MIBs used to configure these IEs and update the configuration of these IEs by reading the information. If the CPE finds out that this information has changed, it shall re-initialize itself. If the MR-BS does not receive either the RNG-REQ or the REG-REQ (with the location information) from the CPE in the allocated opportunity, the MR-BS shall wait until T30 expires before de-registering the CPE.

If the CPE is currently being served by the MR-BS, the MR-BS can force the CPE to delete the pertinent information before expiration of T30 by the following:

a) Send a DREG-CMD to CPE with Action Code = 0x04 (see Table 115) to shutdown the CPE. This is done if the MR-BS detects that the CPE has moved outside the current coverage area of the MR-BS and is not able to service it.

b) Send a DREG-CMD to CPE with Action Code = 0x05 (see Table 115) to force CPE to reinitialize on the current operating channel. This is done if the CPE’s movement is beyond the movement threshold of ±25 m (see policy 8 in Table 234), but the CPE’s movement does not result in a new backup/candidate channel list upon query of the database service.

c) Send a DREG-CMD to the CPE with Action Code = 0x01 and subsequently another DREG-CMD with Action Code = 0x03 (see Table 115) to temporarily disable the CPE’s transmission. This is done, to temporarily disable the CPE’s transmission when a CPE’s movement is within the movement threshold of ±25 m (see Policy 8 in Table 234), but the CPE’s movement does not results in a new backup/candidate channel list upon query of the database service. This avoids having to reinitialize the CPE.

For case a), T30 shall be cleared when the CPE is shutdown. For case b), the T30 shall be reset upon completion of re-registration. For case c), the T30 shall be reset upon sending the DREG-CMD to re-enable CPE.

If the SM (upon interrogating the SSA) detected that the CPE has moved, the MR-BS shall request de- registration by sending a DREG-CMD message to the CPE set with the appropriate Action Code as mentioned above.

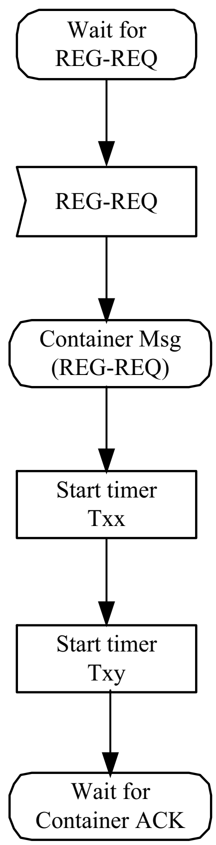

Figure AB1—Wait for REG-REQ and Sending Container message including REG-REQ at a centralized scheduling R-CPE

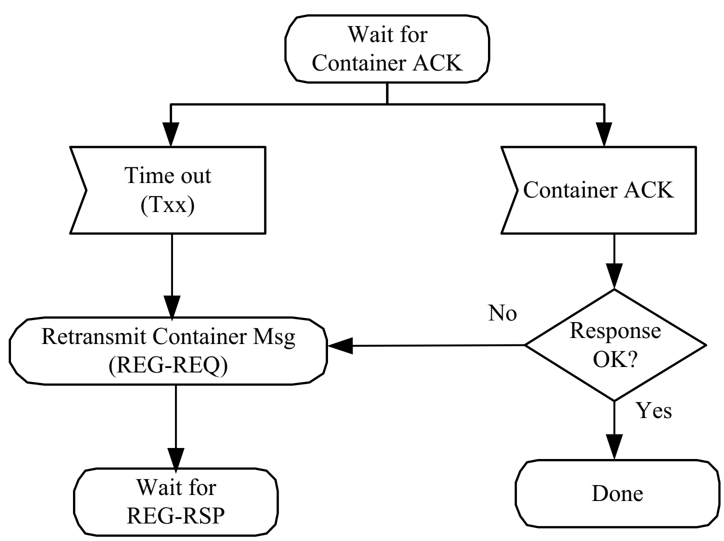

Figure AC1—Wait for Container ACK at a centralized scheduling R-CPE

7.14.3.12 MR-BS transmits channel sets to CPE

The MR-BS shall send the channel sets to the new CPE. The channel sets are described in 10.2.3. The channel sets that are sent to the initializing CPE are the backup channels and the candidate channels. The channel sets are sent in a DCD message, as described in 7.7.1 and in Table 24 to Table 26. The MR-BS shall send DCD channel information elements 11 and 12. Table 26 describes information element 12 as the backup and candidate channel list. It is a prioritized list of the channels with the backup channel set higher in priority than the candidate channel set. The two sets are identified by sending information element 11, which provides the number of the higher prioritized backup channel set. Each channel in DCD information element 12 is characterized by both the channel number.

The distributed scheduling R-CPE shall send the channel sets to the new CPE, which is registered with the distributed scheduling R-CPE. The channel sets are described in 10.2.3. The channel sets that are sent to the initializing CPE are the backup channels and the candidate channels. The channel sets are sent in a DCD message in a DRZ, as described in 7.7.1 and in Table 24 to Table 26. The distributed scheduling R-CPE shall send DCD channel information elements 11 and 12. Table 26 describes information element 12 as the backup and candidate channel list. It is a prioritized list of the channels with the backup channel set higher in priority than the candidate channel set. The two sets are identified by sending information element 11, which provides the number of the higher prioritized backup channel set. Each channel in DCD information element 12 is characterized by both the channel number.

7.14.3.13 Establish IP connectivity

7.14.3.14 Establish time of day

7.14.3.15 Transfer operational parameters

The CPE shall download the CPE's configuration file using TFTP on its own secondary management connection as shown in Figure 47. The CPE shall use an adaptive timeout for TFTP based on binary exponential backoff (IETF RFC 1123 [B19], IETF RFC 2349 [B21]).

When the configuration file download has completed successfully, the CPE shall notify the MR-BS directly or through the R-CPE by transmitting the TFTP-CPLT message on the CPE's primary management connection. Transmissions shall continue successfully until a TFTP-RSP message is received with response "OK" from the MR-BS (see Figure 48 and Figure 49) or the CPE terminates retransmission due to retry exhaustion.

Upon sending a REG-RSP, the MR-BS shall wait for a TFTP-CPLT. If the timer T13 (defined in Table 272) expires, the MR-BS shall restart the registration process (REG-REQ/RSP) with the CPE (see Figure 48). Note that the Timer T26 refers to the time waited for TFTP-RSP. If T26 expires, then TFTP-CPLT is attempted until the maximum number of retries is exhausted. Upon the exhaustion, the CPE shall be deregistered (i.e., forced to reinitialize MAC) by sending a DREG-REQ with Action Code set to 0x05 to force itself to reattempt system access or 0x04 to shut itself down (see Figure 49)

7.14.3.16 Establish dynamic service flows

7.14.3.17 Neighboring network discovery

After a CPE has registered with a WRAN MR-BS, it shall perform neighboring network discovery in order to identify other nearby WRANs and enable efficient self-coexistence, if the CPE has not already done so. The neighboring network discovery involves listening to the medium for CBP packets or MR-BS transmitted by other WRAN MR-BSs. This network discovery mechanism is described in 7.20.1.3.

7.15 Ranging

Insert the following paragraphs after the first paragraph:

An MR-WRAN system provides a further ranging, which will be peformed between CPEs and the distributed scheduling R-CPE as well as between CPEs and the centralized scheduling R-CPE for relaying.

The MR-WRAN ranging can be categorized as the following ranging operations

a) between CPEs and MR-BS (ranging),

b) between CPEs and MR-BS from relaying on the centralized scheduling R-CPE (relay ranging) and

c) between CPEs and the distributed scheduling R-CPE (local ranging).

7.15.1 Downstream management

Move the paragraphs of 7.15.1 into 7.15.1.1

7.15.1.1 Downstream management (MR-BS and CPE)

Insert the new subsection 7.15.1.2 as follows:

7.15.1.2 Local downstream management (distributed scheduling R-CPE and S-CPE)

To maintain efficient local cell operations between the distributed scheduling R-CPE and S-CPEs, the downstream burst profile in a distributed relay zone (DRZ) is determined by the distributed scheduling R-CPE according to the quality of the signal that is received by each S-CPE. To reduce the volume of upstream traffic in a DRZ, the S-CPE monitors the CINR and compares the average value against the allowed range of operation. As shown in Figure 50, threshold levels bound this region. These thresholds parameters are specified in the DCD message transmitted by the distributed scheduling R-CPE, and shall be used by S-CPEs to determine their optimal burst profile. If the received CINR falls outside of the allowed operating region as determined by the threshold parameters, the S-CPE requests a change to a new burst profile using one of the following two methods:

a) If the S-CPE has been granted upstream bandwidth in a DRZ (a data grant allocation to the S-CPE’s Basic FID), the S-CPE shall send a RNG-REQ message in that allocation. The distributed scheduling R-CPE responds with a RNG-CMD message.

b) If a grant is not available and the S-CPE requires a more robust burst profile on the downstream, the S-CPE shall send a RNG-REQ message in a DRZ Initial Ranging interval.

In either of these methods, the message is sent using the S-CPE’s Basic FID. The coordination of message transmission and reception relative to actual change of modulation is different depending upon whether an S-CPE is transitioning to a more or less robust burst profile. Figure AD1 shows the case where an S-CPE is transitioning to a more robust profile, while Figure AE1 illustrates the transition to a less robust profile.

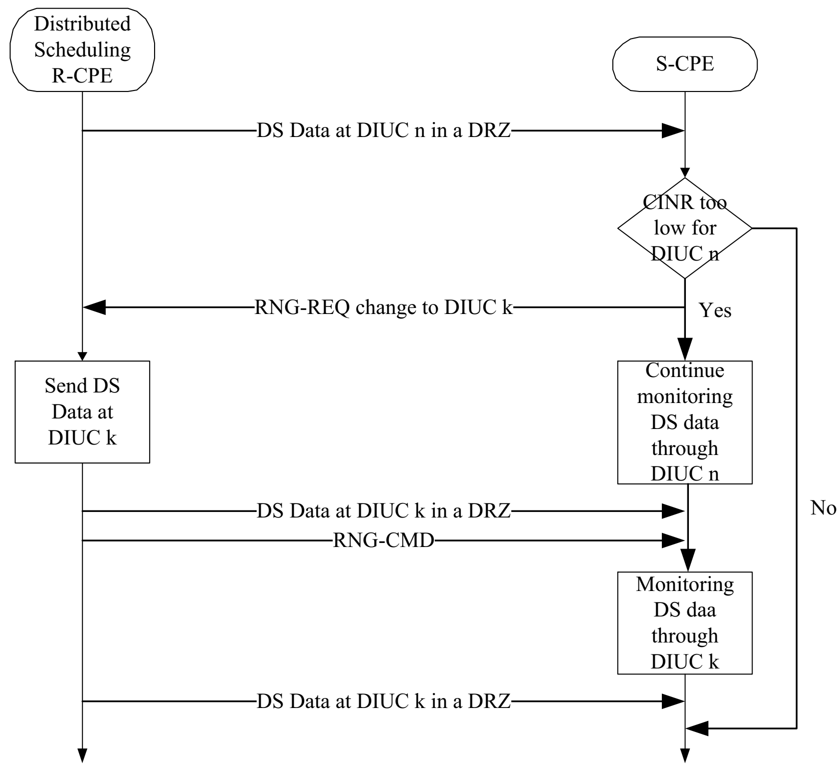

Figure AD1—Change to a more robust profile in a local cell

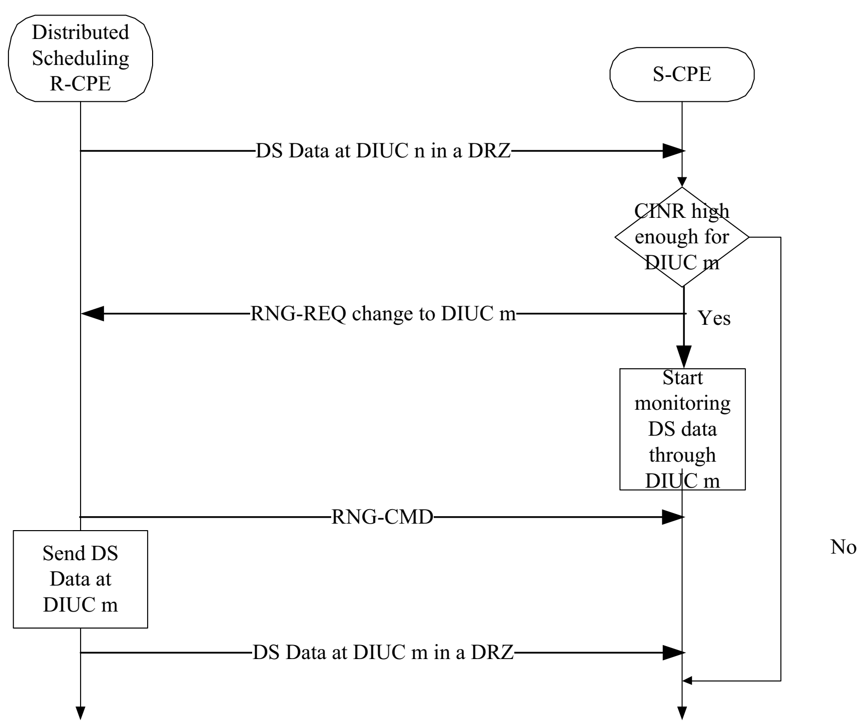

Figure AE1—Change to a less robust profile in a local cell

Insert the new subsection 7.15.1.3 as follows:

7.15.1.3 Relay downstream management (MR-BS and S-CPE via centralized scheduling R-CPE)

Direct downstream from the MR-BS to the S-CPE may transit to relay downstream from the MR-BS to the S-CPE through the centralized scheduling R-CPE as shown in Figure AF1 when the relay downstream has a higher gain rather than the downstream, and vice versa.

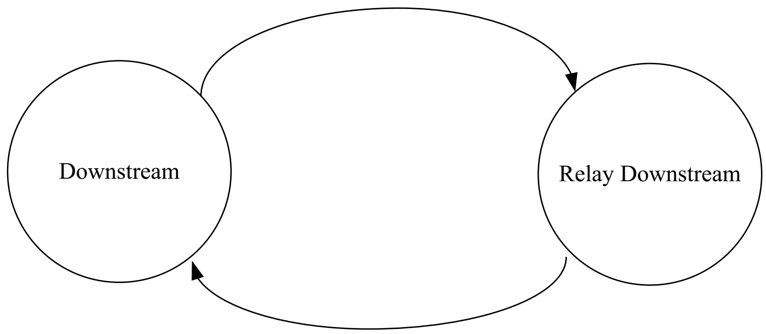

Figure AF1—Transit between downstream and relay downstream

The transit from downstream to relay downstream may be performed from the request of each S-CPE. Before an S-CPE transits downstream to relay downstream, the S-CPE shall confirm the relay downstream burst profile by the following a relay downstream test procedure (see Figure AG1).

a) The S-CPE shall detect a centralized scheduling R-CPE for relay by a CRZ initial ranging procedure.

b) If CRZ inital ranging is successfully finished, the S-CPE requests the MR-BS to start a relay downstream test by sending a Downstream Transit Test Request (DTT-REQ, 7.7.27.1), which includes a selected centralized scheduling R-CPE's SID.

c) The MR-BS sends a Downstream Transit Test Response (DTT-RSP, 7.7.27.2), which indicates the start frame of a bandwidth allocation for a relay downstream test, to the S-CPE.

d) During the allocated bandwidth, the MR-BS transmits test frames to the S-CPE by relaying on the centralized scheduling R-CPE.

e) The S-CPE calculates relay downstream burst profile, and report the calculation result (DST-RPT, 7.7.27.3), which includes a relay downstream bust profile, to the MR-BS.

f) Based on the relay downstream burst profile, the MR-BS decides to transit from downstream to relay downstream, and a Downstream Transmit Confirmation (DST-CFM, 7.7.27.4) is sent to the S-CPE.

Before an S-CPE transit from relay downstream to downstream, on the other hand, the S-CPE shall confirm the downstream burst profile.

a) The S-CPE shall confirm downstream burst profile from monitoring signals such as frame preamble, FCH, DS-MAP transmitted by the MR-BS.

b) The S-CPE reports the downstream burst profile to the MR-BS by using DST-RPT (7.7.27.3).

c) Based on the relay downstream burst profile, the MR-BS decides to transit from relay downstream to downstream, and a DST-CFM (7.7.27.4) is sent to the S-CPE.

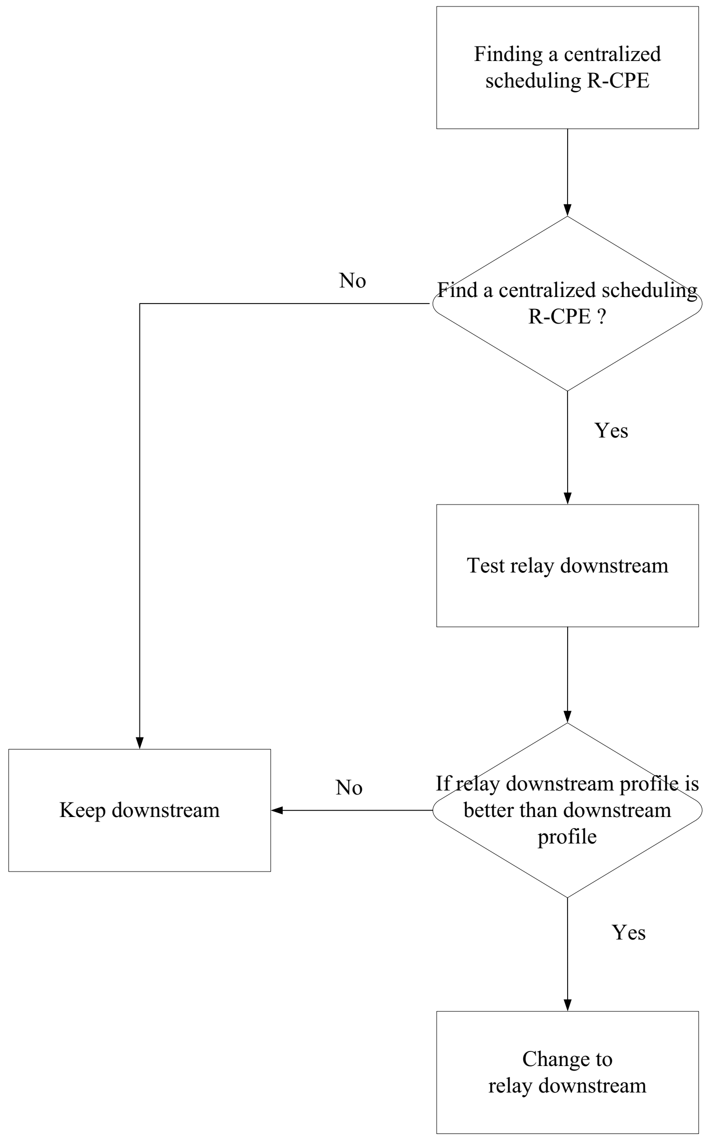

Figure AG1—Relay downstream test procedure

During relay downstream, the S-CPE requests a change to a relay downstream burst profile using one of the following methods.

— If the S-CPE has been granted upstream bandwidth in a CRZ (a data grant allocation to the S-CPE's Basic FID), the S-CPE shall send a RNG-REQ message to the centralized scheduling R-CPE in the bandwidth. If a grant is not available, the S-CPE shall send a RNG-REQ message in a CRZ-Initial Ranging interval to the centralized scheduling R-CPE. The centralized scheduling R-CPE has a following procedure.

—If the centralized scheduling R-CPE has been granted upstream bandwidth in an AZ,

—- the centralized scheduling R-CPE shall send the RNG-REQ message received from the S-CPE to the MR-BS if the centralized scheduling R-CPE has no change of downstream burst profile or,

— the centralized scheduling R-CPE shall send a Container message including the RNG-REQ message received from the S-CPE and the RNG-REG message by oneself to the MR-BS if the centralized scheduling R-CPE requires to change downstream burst profile

—If a grant is not available for the centralized scheduling R-CPE,

—the centralized scheduling R-CPE shall send the RNG-REQ message received from the S-CPE in a CRZ Initial Ranging interval to the MR-BS if the centralized scheduling R-CPE has no change of downstream burst profile or,

—the centralized scheduling R-CPE shall send a Container message including the RNG-REQ message received from the S-CPE and the RNG-REG message by oneself in an Initial Ranging interval to the MR-BS if the centralized scheduling R-CPE requires to change downstream burst profile.

— The MR-BS responds with a RNG-CMD message and broadcasts DCD with relay downstream burst profile.

7.15.2 Upstream management

Change the paragraph as follows:

Upstream ranging management consists of two procedures: initial ranging and periodic ranging. Initial ranging (see 7.14) allows a CPE joining the network to acquire correct transmission parameters, such as time offset and Tx EIRP level, so that the CPE can communicate with the BS/MR-BS or the distributed scheduling R-CPE. Initial Ranging is categorized as initial ranging between CPEs and MR-BS, relay initial ranging between CPEs and MR-BS from relaying on the centralized scheduling R-CPE, and local initial ranging between CPEs and the distributed scheduling R-CPE. The WRAN PHY specifies a ranging subchannel and a set of special pseudo-noise ranging codes. Initial ranging is performed by using initial ranging codes at initial ranging subchannel in an AZ, relay initial ranging is performed by using CRZ inital ranging codes at relay initial ranging subchannel in a CRZ, and local initial ranging is performed by DRZ initial ranging codes at local initial ranging subchannel in a DRZ. Subsets of codes shall be allocated in the UCD channel encoding for initial ranging, periodic ranging requests, and BRs so that the BS/MR-BS can determine the purpose of the received code by the subset to which the code belongs. CPEs that wish to perform one of the aforementioned operations shall select, with equal probability, one of the codes of the appropriate subset, modulate it onto the ranging subchannel, and subsequently transmit in the ranging slot selected with equal probability from the available ranging slots on the upstream subframe. A CPE shall select one Ranging Slot from all available ranging slots in the upstream frame using a uniform random process. Details on the modulation and ranging codes are specified in 9.9.2. Following initial ranging, periodic ranging allows the CPE to adjust transmission parameters so that it can maintain upstream communications with the BS/MR-BS.

The following subclauses summarize the general algorithm for initial ranging and periodic ranging.

Insert new subclause 7.15.2.1a as follows:

7.15.2.1a CDMA initial ranging and automatic adjustments (MR-BS and CPE)

A CPE that wishes to perform initial ranging with CDMA code in an AZ shall take the following steps:

a) The CPE, after acquiring downlink synchronization and uplink transmission parameters from the MR-BS in an AZ, shall select one Ranging Slot using the random backoff. The random backoff shall use a binary truncated exponent algorithm. After selecting the Ranging Slot, the CPE shall choose a Ranging Code (from the Initial Ranging domain) using a uniform random process. The selected Ranging Code is sent to the BS/MR-BS (as a CDMA code) in the selected Ranging Slot.

b) The BS/MR-BS cannot tell which CPE sent the CDMA ranging request; therefore, upon successfully receiving a CDMA ranging code, the BS/MR-BS broadcasts a ranging response message (RNG-CMD) that advertises the received ranging code as well as the ranging slot (OFDMA symbol number, etc.) where the CDMA ranging code has been identified. This information is used by the CPE that sent the CDMA ranging code to identify the ranging response message that corresponds to its ranging request. The ranging response message contains all the needed adjustments (e.g., time, EIRP, and possibly frequency corrections) and a status notification.

c) Upon receiving a RNG-CMD message with the "Continue" status, the CPE shall continue the ranging process as done on the first entry (using random selection rather than random backoff) with ranging codes randomly chosen from the initial ranging domain sent on the ranging slots.

d) When the BS/MR-BS receives an initial-ranging CDMA code that requires no corrections, the BS/MR-BS shall provide BW allocation for the CPE using the CDMA_Allocation_IE to send an RNG-REQ message. Sending the RNG-CMD message with status "Success" is optional.

e) The initial ranging process is over after receiving RNG-CMD message, which includes a valid SID (following a RNG-REQ transmission on a CDMA Allocation IE). If this RNG-CMD message includes a "continue" indication, the ranging process should be continued using the ranging mechanism.

f) The timeout required for the CPE to wait for RNG-CMD, following or not following a CDMA Allocation IE, is defined by the timer T3.

Insert new subclause 7.15.2.1b as follows:

7.15.2.1b CDMA local initial ranging and automatic adjustments (distributed scheduling R-CPE and S-CPE)

A CPE is acquiring local downlink synchronization and local uplink transmission parameters from distributed scheduling R-CPE only.

A CPE that wishes to perform local initial ranging with CDMA code in a DRZ shall take the following steps:

a) The CPE, after acquiring downlink synchronization and uplink transmission parameters from the distributed scheduling R-CPE, shall select one Ranging Slot in a DRZ (DRZ Ranging Slot) using the random backoff. The random backoff shall use a binary truncated exponent algorithm. After selecting the DRZ Ranging Slot, the CPE shall choose a DRZ Ranging Code (from the DRZ Initial Ranging domain) using a uniform random process. The selected DRZ Ranging Code is sent to the distributed scheduling R-CPE (as a CDMA code) in the selected DRZ Ranging Slot.

b) The distributed scheduling R-CPE cannot tell which CPE sent the CDMA ranging request; therefore, upon successfully receiving a DRZ ranging code, the distributed scheduling R-CPE broadcasts a RNG-CMD message that advertises the received DRZ ranging code as well as the DRZ ranging slot (OFDMA symbol number, etc.) where the DRZ ranging code has been identified. This information is used by the CPE that sent the DRZ ranging code to identify the RNG-CMD message that corresponds to its ranging request. The RNG-CMD message contains all the needed adjustments (e.g., time, EIRP, and possibly frequency corrections) and a status notification.

c) Upon receiving a RNG-CMD message with the "Continue" status, the CPE shall continue the ranging process as done on the first entry (using random selection rather than random backoff) with ranging codes randomly chosen from the DRZ initial ranging domain sent on the DRZ Ranging Slots.

d) When the distributed scheduling R-CPE receives an initial-ranging CDMA code that requires no corrections, the distributed scheduling R-CPE shall provide BW allocation in a DRZ for the CPE using the CDMA_Allocation_IE to send an RNG-REQ message. Sending the RNG-CMD message with status "Success" is optional.

e) The DRZ initial ranging process is over after receiving RNG-CMD message, which includes a valid SID (following a RNG-REQ transmission on a CDMA Allocation IE). The distributed scheduling R-CPE shall choose one SID into a Local SID Group for the CPE's SID. If this RNG-CMD message includes a “continue” indication, the ranging process should be continued using the ranging mechanism.

f) The timeout required for the CPE to wait for RNG-CMD, following or not following a CDMA Allocation IE, is defined by the timer T3.

Insert new subclause 7.15.2.1c as follows:

7.15.2.1c CDMA relay initial ranging and automatic adjustments (centralized scheduling R-CPE and S-CPE)

A CPE enabling to acquire downlink synchronization and uplink transmission parameters from the MR-BS in an AZ shall perform initial ranging with CDMA code to the MR-BS. While, the initial ranging request from the CPE may not arrive to the MR-BS due to the transmission power constraint of the CPE. In this case, a certain centralized scheduling R-CPE may perform y initial ranging for the CPE.

a) The CPE, after acquiring downlink synchronization and uplink transmission parameters from the BS/MR-BS, may select one Ranging Slot in a CRZ (CRZ Ranging Slot) using the random backoff. The random backoff shall use a binary truncated exponent algorithm. After selecting the CRZ Ranging Slot, the CPE shall choose a CRZ Ranging Code (from the CRZ initial Ranging domain) for the CRZ Ranging Slot using a uniform random process. The selected CRZ Ranging Code is sent to the centralized scheduling R-CPE in the selected CRZ Ranging Slot. In this stage, the CPE is not aware whether the centralized scheduling R-CPE exists within the transmission range of the CPE.

b) The centralized scheduling R-CPE may receive as many CRZ Ranging Codes in the CRZ Ranging Slot. The centralized scheduling R-CPE cannot tell which CPE sent the ranging request; therefore, upon successfully receiving a CRZ ranging code during the CRZ Ranging Slot, the centralized scheduling R-CPE broadcasts a RNG-CMD message that advertises the received CRZ ranging code as well as the received CRZ ranging slot (OFDMA symbol number, etc.) where the CRZ ranging code has been identified. This information is used by the CPE that sent the CRZ ranging code to identify the RNG-CMD message that corresponds to its ranging request. The RNG-CMD message contains all the needed adjustments (e.g., time, EIRP, and possibly frequency corrections) and a status notification. For the transmission of RNG-CMD to the CPE, a centralized scheduling R-CPE shall request bandwidth to a BS/MR-BS by using an Extended Bandwidth Request Subheader (7.6.1.2.1a).

c) When the CPE may receive several RNG-CMD messages sent from the centralized scheduling R-CPEs, the CPE will choose one RNG-CMD into the received RNG-CMDs for the further ranging.

d) Upon receiving a RNG-CMD message with the “Continue” status from the selected centralized scheduling R-CPE, the CPE shall continue the ranging process as done on the first entry with CRZ ranging codes on the CRZ ranging slot to the centralized scheduling R-CPE.

e) When the centralized scheduling R-CPE receives a CRZ ranging code that no corrections, the centralized scheduling R-CPE sends a RNG-CMD with the “Success” to the CPE. In this stage, a valid SID is not assigned for the CPE. Thus, the CPE sends RNG-REQ to the centralized scheduling R-CPE in a CRZ ranging slot.

f) The centralized scheduling R-CPE shall sends a Container message including the received RNG-REQ message from the CPE to the BS/MR-BS.

g) Upon receiving the Container message, the MR-BS shall return a Container ACK message with a confirmation code for the received messages to the centralized scheduling R-CPE. If the confirmation code for a RNG-REQ message is not “success”, the centralized scheduling R-CPE shall retransmit the RNG-REQ message to the BS/MR-BS.

h) When successfully receiving the RNG-REQ, the BS/MR-BS shall provide a valid SID for the CPE by sending RNG-CMD message. If this RNG-CMD message includes a “continue” indication, the ranging process should be continued using the ranging mechanism.

i) The timeout required for the CPE to wait for RNG-CMD is defined by the timer T3.

7.15.2.2 CDMA Periodic ranging and automatic adjustments

Insert new subclause 7.15.2.2a as follows:

7.15.2.2a CDMA periodic ranging and automatic adjustments (MR-BS and CPE)

The following summarizes the general algorithm for CDMA periodic ranging between the BS/MR-BS and the CPE:

a) The CPE shall choose randomly a Ranging Slot (with random selection with equal probability from available Ranging Slots in a single frame) at the time in an AZ to perform the ranging, and then it chooses randomly a Periodic Ranging Code and sends it to the BS/MR-BS (as a CDMA code).

b) If the CPE does not receive a response, the CPE may send a new CDMA code at the next appropriate ranging transmission opportunity at one step higher EIRP level.

c) The BS/MR-BS cannot tell which CPE sent the CDMA ranging request; therefore, upon successfully receiving a CDMA periodic ranging code, the BS broadcasts a ranging response (RNG-CMD) message that advertises the received periodic ranging code as well as the ranging slot (OFDMA symbol number, etc.) where the CDMA periodic ranging code has been identified. This information is used by the CPE that sent the CDMA periodic ranging code to identify the ranging response message that corresponds to its ranging request. The ranging response message contains all the needed adjustments (e.g., time, EIRP, and possibly frequency corrections) and a status notification.

d) Upon receiving a RNG-CMD message with the "Continue" status, the CPE shall continue the ranging process with further periodic ranging codes randomly chosen. Upon receiving an RNG-CMD message with success status, the CPE shall restart timer T4 with the appropriate value depending whether the CPE is fixed or portable (see Table 273).

e) The BS/MR-BS may send an unsolicited RNG-CMD as a response to a CDMA-based bandwidth-request or any other data transmission from the CPE.

f) Upon timeout of the CPE internal T4 timer, the CPE shall perform Periodic Ranging according to the procedure above.

g) When the CPE receives an unsolicited RNG-CMD message, it shall reset the periodic ranging timer and adjust the parameters (timing, EIRP, etc.) as notified in the RNG-CMD message.

Insert new subclause 7.15.2.2b as follows:

7.15.2.2b CDMA periodic ranging and automatic adjustments (distributed scheduling R-CPE and CPE)

The following summarizes the general algorithm for CDMA periodic ranging between the distributed scheduling R-CPE and the CPE in a local cell:

a) a)The CPE shall choose randomly a Ranging Slot (with random selection with equal probability from available Ranging Slots in a single frame) at the time in a DRZ to perform the ranging, and then it chooses randomly a DRZ Periodic Ranging Code and sends it to the distributed scheduling R-CPE (as a CDMA code).

b) If the CPE does not receive a response, the CPE may send a new CDMA code at the next appropriate ranging transmission opportunity at one step higher EIRP level.

c) The distributed scheduling R-CPE cannot tell which CPE sent the CDMA ranging request; therefore, upon successfully receiving a CDMA periodic ranging code, the distributed scheduling R-CPE broadcasts a ranging response (RNG-CMD) message that advertises the received DRZ periodic ranging code as well as the DRZ ranging slot (OFDMA symbol number, etc.) where the CDMA periodic ranging code has been identified. This information is used by the CPE that sent the CDMA periodic ranging code to identify the ranging response message that corresponds to its ranging request. The ranging response message contains all the needed adjustments (e.g., time, EIRP, and possibly frequency corrections) and a status notification.

d) Upon receiving a RNG-CMD message with the "Continue" status, the CPE shall continue the ranging process with further periodic ranging codes randomly chosen. Upon receiving an RNG-CMD message with success status, the CPE shall restart timer T4 with the appropriate value depending whether the CPE is fixed or portable (see Table 273).

e) The distributed scheduling R-CPE may send an unsolicited RNG-CMD as a response to a CDMA-based bandwidth-request or any other data transmission from the CPE.

f) Upon timeout of the CPE internal T4 timer, the CPE shall perform Periodic Ranging according to the procedure above.

g) When the CPE receives an unsolicited RNG-CMD message, it shall reset the periodic ranging timer and adjust the parameters (timing, EIRP, etc.) as notified in the RNG-CMD message.

Insert new subclause 7.15.2.2c as follows:

7.15.2.2c CDMA periodic ranging and automatic adjustments (centralized scheduling R-CPE and CPE)

The following summarizes the general algorithm for CDMA periodic ranging between the centralized scheduling R-CPE and the CPE:

a) The CPE shall choose randomly a Ranging Slot (with random selection with equal probability from available Ranging Slots in a single frame) at the time in a CRZ to perform the ranging, and then it chooses randomly a CRZ Periodic Ranging Code and sends it to the centralized scheduling R-CPE (as a CDMA code).

b) If the CPE does not receive a response, the CPE may send a new CDMA code at the next appropriate ranging transmission opportunity at one step higher EIRP level.

c) The centralized scheduling R-CPE cannot tell which CPE sent the CDMA ranging request; therefore, upon successfully receiving a CDMA periodic ranging code, the centralized scheduling R-CPE broadcasts a ranging response (RNG-CMD) message that advertises the received CRZ periodic ranging code as well as the CRZ ranging slot (OFDMA symbol number, etc.) where the CDMA periodic ranging code has been identified. This information is used by the CPE that sent the CDMA periodic ranging code to identify the ranging response message that corresponds to its ranging request. The ranging response message contains all the needed adjustments (e.g., time, EIRP, and possibly frequency corrections) and a status notification. For the transmission of RNG-CMD to the CPE, a centralized scheduling R-CPE shall request bandwidth to a BS/MR-BS by using an Extended Bandwidth Request Subheader (7.6.1.2.1a).

d) Upon receiving a RNG-CMD message with the "Continue" status, the CPE shall continue the ranging process with further periodic ranging codes randomly chosen. Upon receiving an RNG-CMD message with success status, the CPE shall restart timer T4 with the appropriate value depending whether the CPE is fixed or portable (see Table 273).

e) The centralized scheduling R-CPE may send an unsolicited RNG-CMD as a response to a CDMA-based bandwidth-request or any other data transmission from the CPE.

f) Upon timeout of the CPE internal T4 timer, the CPE shall perform Periodic Ranging according to the procedure above.

g) When the CPE receives an unsolicited RNG-CMD message, it shall reset the periodic ranging timer and adjust the parameters (timing, EIRP, etc.) as notified in the RNG-CMD message.

7.16 Channel descriptor management

Change the paragraph as follows:

As previously presented, channel descriptor messages (i.e., DCD and UCD) are broadcast by the BS/MR-BS to all associated CPEs at periodic intervals as well as broadcast by the distributed scheduling R-CPE to the associated CPEs in its local cell at periodic interval. Among other things, these channel descriptors define burst profiles, which are used by US-MAP and DS-MAP messages for allocating upstream and downstream transmissions, respectively. Once broadcast by the BS/MR-BS or the distributed scheduling R-CPE and received by its associated CPEs, a given channel descriptor shall remain valid until a new channel descriptor message with a different value for the Configuration Change Count field, is again broadcast by the BS/MR-BS or or the distributed scheduling R-CPE, respectively. When this happens, this new channel descriptor shall overwrite all the information of the previous descriptor. When the distributed scheduling R-CPE receives a new downstream channel descriptor for channel switching from the BS/MR-BS, the distributed scheduling R-CPE shall immediately broadcast the new downstream channel descriptor with the same information of channel switching (i.e., channel action, action mode, and action frame number) to the associated CPEs in the local cell in order to the operating channel in the local cell be changed to the same channel of the BS/MR-BS's cell at the same time.

Once channel descriptors are known to all CPEs in an IEEE 802.22b BS/MR-BS's cell, the BS/MR-BS shall set the UCD/DCD Count value in an AZ, contained in US-MAP and DS-MAP messages, equal to the Configuration Change Count of the desired channel descriptor. Once channel descriptors are known to all CPEs in the distributed scheduling R-CPE's local cell, the distributed scheduling R-CPE shall set the UCD/DCD Count value in a DRZ, contained in US-MAP and DS-MAP messages, equal to the Configuration Change Count of the desired channel descriptor. This way, a BS/MR-BS and a distributed scheduling R-CPE can easily indicate to its associated CPEs which burst profile is to be used for a given allocation, and hence provide high flexibility to the BS/MR-BS or the distributed scheduling R-CPE in controlling which burst profile to use at any given time by simply changing the UCD/DCD Count value.

Finally, note that the Configuration Change Count shall be incremented by 1 modulo 256 for every new migration of channel descriptor. After issuing a DS-MAP or US-MAP message with the Configuration Change Count equal to that of the new generation, the old channel descriptor ceases to exist and the BS/MR-BS and the distributed scheduling R-CPE shall not refer to it anymore. When migrating from one generation to the next, the BS/MR-BS and the distributed scheduling R-CPE shall schedule the transmissions of the UCD and DCD messages in such a way that each CPE has the possibility to successfully hear it at least once.

7.18 QoS

7.18.9.3 Dynamic Service Addition

7.18.9.3.1 CPE-initiated DSA

Insert the new subsection 7.18.9.3.1.1 as follows:

7.18.9.3.1.1 MR-BS and R-CPE behaviour during CPE-initiated DSA

When a DSA-REQ message is sent from a CPE, the centralized scheduling R-CPE and the MR-BS may deal with the message in the following way:

- The centralized scheduling R-CPE may add the acceptable QoS parameter set to the DSA-REQ if it cannot support the requested QoS parameter set. It then sends the DSA-REQ to the MR-BS using the primary management CID of the CPE.
- The centralized scheduling R-CPE may include Per-RS QoS TLV in the DSA-REQ to the MR-BS. The Per-RS QoS TLV in this case represents the maximum latency at the centralized scheduling R-CPE to relay the requested QoS parameter set. If the MR-BS receives Per-RS QoS TLV, the MR-BS shall consider the value in Per-RS QoS TLV and ones in the requested QoS parameter set.

- The centralized scheduling R-CPE may get the updated SF parameters and confirmation code from DSA-RSP and DSA-ACK sent from the MR-BS and the CPE, respectively.
- Upon receiving the DSA-REQ from the CPE via the centralized scheduling R-CPE, the MR-BS sends back a response to the CPE in the same way defined for non-relay systems. The admission control algorithm is out of scope of this standard.
- If the service flow parameters are changed, the MR-BS shall send a DSC-REQ to the centralized scheduling R-CPE before sending DSA-RSP to the SS.

7.18.9.3.2 BS-initiated DSA

Insert the new subsection 7.18.9.3.2.1 as follows:

7.18.9.3.2.1 MR-BS and R-CPE behaviour during MR-BS-initiated DSA

When an MR-BS initiates a DSA-REQ message to a CPE via a centralized scheduling R-CPE, the centralized scheduling R-CPE and the MR-BS may deal with the message in the following way.

- If the service flow parameters are changed, the MR-BS shall send a DSC-REQ to the centralized scheduling R-CPE before sending the DSA-REQ to the CPE in the same manner as defined above.
- The MR-BS may include Per-RS QoS TLV in the DSA-REQ to centralized scheduling R-CPE. If the centralized scheduling R-CPE receives Per-RS QoS TLV, the centralized scheduling R-CPE shall use values in Per-RS QoS TLV instead of the ones in the service flow parameters.
- When the centralized scheduling R-CPE can support the requested QoS parameter set, it sends the DSA-REQ to the CPE using the primary management CID of the CPE.
- When the centralized scheduling R-CPE cannot support the requested QoS parameter set in the DSA-REQ, it sends DSA-RSP with CC set to reject-RS-not-supported-parameter-value to the MR-BS indicating that it can support the requested QoS parameter set. The DSA-RSP may contain the acceptable QoS parameter set the centralized scheduling R-CPE can support.
- The centralized scheduling R-CPE may get the updated SF parameters and confirmation code from DSA-RSP and DSA-ACK sent from the CPE and the MR-BS, respectively.

7.18.9.4 Dynamic Service Change

7.18.9.4.1 CPE-initiated DSC

Insert the new subsection 7.18.9.4.1.1 as follows:

7.18.9.4.1.1 MR-BS and centralized scheduling R-CPE behaviour during CPE-initiated DSC

When a DSC-REQ message is sent from a CPE, a centralized scheduling R-CPE and the MR-BS may deal with the message in the following way:

- The centralized scheduling R-CPE may add the acceptable QoS parameter set to the DSC-REQ if it cannot support the requested QoS parameter set. It then sends the DSC-REQ to the MR-BS using the primary management CID of the CPE.
- The centralized scheduling R-CPE may include Per-RS QoS TLV in the DSC-REQ to the MR-BS. The Per-RS QoS TLV in this case represents the maximum latency at the centralized scheduling R-CPE to relay the requested QoS parameter set. If the MR-BS receives Per-RS QoS TLV, the MR-BS shall consider the value in Per-RS QoS TLV and ones in the requested QoS parameter set.
- The centralized scheduling R-CPE may get the updated SF parameters and confirmation code from DSC-RSP and DSC-ACK sent from the MR-BS and the CPE, respectively.

- Upon receiving the DSC-REQ from the CPE via the centralized scheduling R-CPE, the MR-BS sends back a response to the CPE in the same way defined for non-relay systems. The admission control algorithm is out of scope of this standard.
- If the service flow parameters are changed, the MR-BS shall send a DSC-REQ to the centralized scheduling R-CPE before sending DSC-RSP to the CPE.

7.18.9.4.2 BS-initiated DSC

Insert the new subsection 7.18.9.4.2.1 as follows:

7.18.9.4.2.1 MR-BS and centralized scheduling R-CPE behaviour during MR-BS-initiated DSC

When an MR-BS initiates a DSC-REQ message to a CPE via a centralized scheduling R-CPE, the centralized scheduling and the MR-BS may deal with the message in the following way:

- If the service flow parameters are changed, the MR-BS shall send a DSC-REQ to the centralized scheduling R-CPE before sending the DSC-REQ to the CPE.
- The MR-BS may include Per-RS QoS TLV in DSC-REQ to centralized scheduling R-CPE. If the centralized scheduling R-CPE receives Per-RS QoS TLV, the centralized scheduling R-CPE shall use values in Per-RS QoS TLV instead of the ones in the service flow parameters.
- When the centralized scheduling R-CPE can support the requested QoS parameter set, it sends the DSC-REQ to the CPE using the primary management CID of the CPE.
- When the centralized scheduling R-CPE cannot support the requested QoS parameter set in the DSC-REQ, it sends DSC-RSP with CC set to reject-RS-not-supported-parameter-value to the MR-BS indicating that it cannot support the requested QoS parameter set. The DSC-RSP may contain the acceptable QoS parameter set the centralized scheduling R-CPE can support.
- The centralized scheduling R-CPE may get the updated SF parameters and confirmation code from DSC-RSP and DSC-ACK sent from the CPE and the MR-BS, respectively.

7.18.9.5 Dynamic Service Deletion

7.18.9.5.1 CPE-initiated DSD

Insert the new subsection 7.18.9.5.1.1 as follows:

7.18.9.5.1.1 MR-BS and centralized scheduling R-CPE behaviour during CPE-initiated DSD

When a DSD-REQ message is sent from a CPE, the centralized scheduling R-CPE relays it to the MR-BS using the primary management CID of the CPE. After processing the DSD-REQ, the MR-BS replies with a DSD-RSP using the CPE primary management CID. When the centralized scheduling R-CPE receives the DSD-RSP, it deletes the service flow information and relays it to the CPE.

7.18.9.5.2 BS-initiated DSD

Insert the new subsection 7.18.9.5.2.1 as follows:

7.18.9.5.2.1 MR-BS and centralized scheduling R-CPE behaviour during MR-BS-initiated DSD

When an MR-BS initiates a DSD-REQ message to a CPE via a centralized scheduling R-CPE using the primary management CID of the CPE, the centralized scheduling R-CPE relays it to the CPE using the primary management CID of the CPE. When the centralized scheduling R-CPE receives a DSD-RSP sent from the CPE, it deletes the service flow information and relays it to the MR-BS.

7.19 Incumbent protection

Insert the following paragraph after the second paragraph of 7.19:

An IEEE 802.22b system shall support incumbent protection on relay connection between MR-BS and CPEs. The incumbent protection procedures for the case that the direct connection exists between MR-BS and CPEs shall follow the operations described from 7.19.1 to 7.19. 6. The measurement management and notification procedures of incumbent protection for a relay network are shown in 7.19.2.1 and 7.19.4.2, respectively.

7.19.2.1 Measurements management for a relay network

Measurement management is to perform a wide range of measurement activities, either related to incumbent detection or to self-coexistence.

In an IEEE 802.22b network, measurement requests can be performed from the MR-BS.

When a centralized scheduling R-CPE receives BLM-REQ from the MR-BS, it shall send it to the destination CPE. The CPE shall report back to the MR-BS on relaying the centralized scheduling R-CPE with a BLM-REP message that contains measurement results. Then, the MR-BS sends the corresponding acknowledgment (BLM-ACK) on the next downstream opportunity following the reception of the measurement report (see Figure AH1).

When a distributed scheduling R-CPE receives BLM-REQ from the MR-BS, it shall perform measurement within the local cell by sending BLM-REQ to the CPE. The CPE shall report back to the MR-BS on relaying the distributed scheduling R-CPE with the BLM-REP message that contains measurement results. Then, the BS/MR-BS sends the corresponding acknowledgment (BLM-ACK) on the next downstream opportunity following the reception of the measurement report (see Figure AH1).

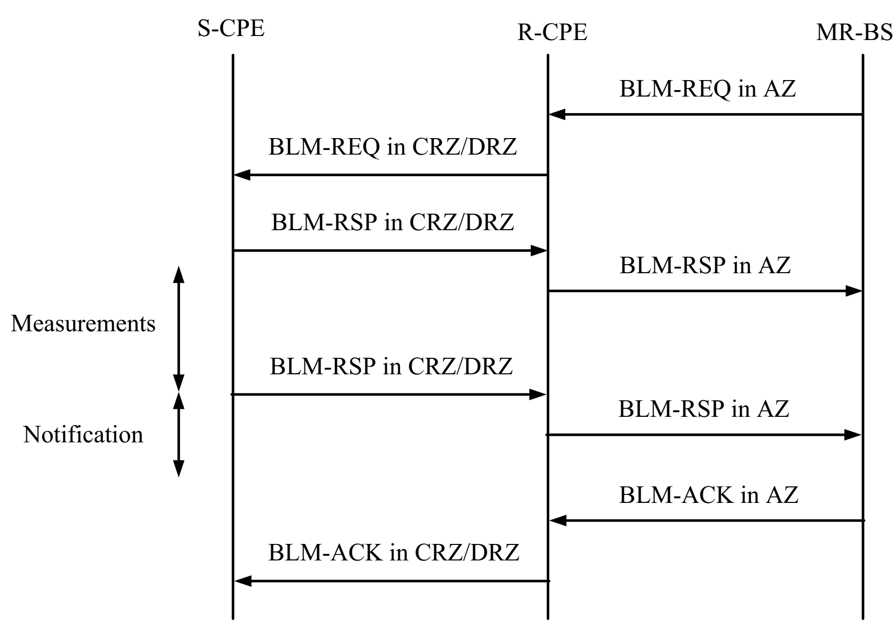

Figure AH1—Measurement message flow between MR-BS and CPE through R-CPE

7.19.4.2 Measurement report and notification for a relay network

The CPE may have an upstream bandwidth allocation in a CRZ to send the UCS notification to the centralized scheduling R-CPE, or may have an upstream bandwidth allocation in a DRZ to send UCS notification to the distributed scheduling R-CPE. Those R-CPEs shall relay UCS notification transmitted by the CPE to the MR-BS in an AZ by using one of UCS notifications that are upstream bandwidth allocation, opportunistic UCS notification, and CDMA based UCS notification.

The CPE may use an opportunistic UCS notification interval in a CRZ to send the UCS notification to the centralized scheduling R-CPE, or may use an opportunistic UCS notification interval in a DRZ to send UCS notification to the distributed scheduling R-CPE. Those R-CPEs shall relay UCS notification transmitted by the CPE to the MR-BS in an AZ by using one of UCS notifications that are upstream bandwidth allocation, opportunistic UCS notification, and CDMA based UCS notification.

Upon reception of UCS notification codes from CPEs, a centralized scheduling R-CPE shall relay the UCS notification codes to the MR-BS. The MR-BS does not respond with an allocation on the CPE's SID and Basic FID since it is not yet known at this time. Instead, it broadcasts a CDMA_Allocation_IE, which specifies the code and allocation in a CRZ that was used by the CPE. This allows the CPE to determine whether it has been given an allocation by matching the CDMA code that the used for the CDMA UCS notification message and the code broadcast by the BS. The CPE shall use the allocation to transmit a MAC PDU to the centralized scheduling R-CPE with the UCS field in the MAC header properly set. The centralized scheduling R-CPE shall notify the UCS notification to the MR-BS by using any possible ways of UCS notification (7.19.4.1.2.1, 7.19.4.1.2.2).

Upon reception of UCS notification codes, a distributed scheduling R-CPE does not respond with an allocation on the CPE's SID and Basic FID since it is not yet known at that time. Instead, it broadcasts a CDMA_Allocation_IE, which specifies the code that was used by the CPE. This allows the CPE to determine whether it has been given an allocation by matching the CDMA code that the used for the CDMA UCS notification message and the code broadcast by the distributed scheduling R-CPE. The CPE shall use the allocation to transmit a MAC PDU with the UCS field in the MAC header properly set. The distributed scheduling R-CPE shall notify the UCS notification to the MR-BS by using any possible ways of UCS notification (7.19.4.1.2.1, 7.19.4.1.2.2).

7.20 Self-coexistence

Change the last paragraph as follows:

The Coexistence Beacon protocol (CBP) is the transport mechanism for the coexistence elements supported in this standard and CBP packets can be transmitted over-the-air or through the backhaul. The BSs and CPEs shall be capable of transmitting and receiving CBP packets over-the-air as specified in 9.5. In order to implement eventual coexistence mechanism over the backhaul, the CBP information from IEEE 802.22 base stations shall be encapsulated in IP packets for transport over the backhaul. A WRAN runs in normal mode by default and transits to self-coexistence mode when the WRAN can detect and decode an SCH or a CBP burst from an adjacent WRAN cell on PHY Mode 1. A WRAN runs in normal mode by default and transits to self-coexistence mode when the WRAN can detect and decode an Extended Frame Control Header or a CBP burst from an adjacent WRAN cell on PHY Mode 2.

7.20.1 Coexistence Beacon Protocol (CBP)

7.20.1.1 CBP packet structure (PHY Mode 1)

Change the first sentence of the first paragraph as follows:

The structure of a CBP packet (i.e., CBP PHY PDU) for PHY Mode 1 is shown in Figure 100.

Insert new subclause 7.20.1.1a as follows:

7.20.1.1a CBP packet structure (PHY Mode 2)

The structure of a CBP packet (i.e., CBP PHY PDU) for PHY Mode 2 is shown in Figure AI1. The burst starts with a CBP preamble that shall be common across all 802.22b networks (see 9.4.1.1), and that shall be different from the frame preamble. After the CBP preamble, the CBP MAC PDU as described in Table 8 shall be transmitted. The CBP MAC PDU shall be two OFDM symbols long.

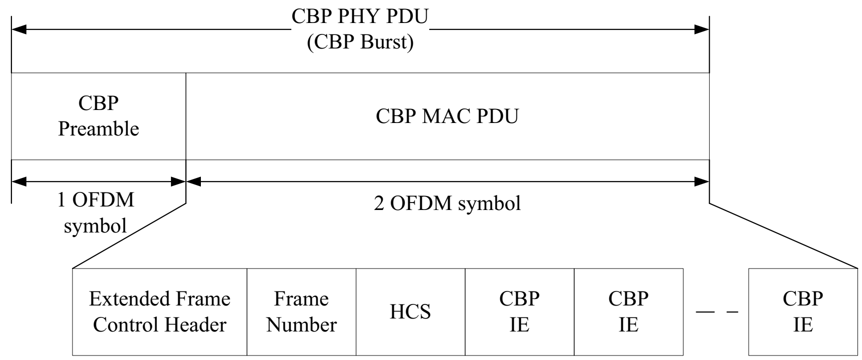

Figure AI1—Structure of a CBP packet

By including the Extended Frame Control Header (which contains information about the 802.22b cell) as part of the beacon MAC header, the transmitting CPE or MR-BS conveys necessary information to allow neighboring network discovery and coordination of quiet periods and SCWs. Including the Extended Frame Control Header is a way to advertise the schedule of QPs and SCWs to CPEs in other neighboring cells.

The Extended Frame Control Header information is needed in situations where WRANs are operating in different channels as well as when they are operating co-channel or adjacent channels. In the first case, the Extended Frame Control Header information obtained through detecting and demodulation the Extended Frame Control Header or through reception of the CBPs allows other WRANs to discover the schedule of QPs, which can be used for out-of-band sensing. In case WRANs are operating co-channel or on adjacent channels, the Extended Frame Control Header, received through the CBPs, will signal the schedule of QPs and SCWs in addition to containing other IEs that can be used to signal frame allocations, when needed.

For communication using CBP over the backhaul, the CBP MAC PDU (see Figure 100) shall be encapsulated into an IP packet.

The MR-BS controls access to the medium within the SCW. The MR-BS shall decide which CPEs transmit CBP packets in each scheduled active UIUC=0.

7.20.2 CBP-based inter-BS communication

7.20.3 Mechanism for inter-BS self-coexistence

Insert new subclause 7.20.4 as follows:

7.20.4 Self-coexistence for a relay network

Self-coexistence in 802.22b networks shall follow the mechanisms described in 7.20.1, 7.20.2, and 7.20.3, which will be performed by the negotiation of the MR-BS and the neighboring MR-BSs.

For self-coexistence in 802.22b networks, the SCW shall be synchronized at all CPEs within a 802.22b network. For synchronizing SCW, an MR-BS shall transmit SCH in PHY Mode 1 or Extended Frame Control Header in PHY Mode 2. When CPEs receives SCH or Extended Frame Control Header from the MR-BS, they synchronize the SCW within a 802.22b network. When a distributed scheduling R-CPE receives the SCW schedule information from the MR-BS, it shall arrange the SCW schedule within a local cell by sending the same information of SCH or Extended Frame Control Header received from the MR-BS to the CPEs in a local cell.

7.20.4.1 Mechanism for inter-MR-BS self-coexistence on a relay network

The self-coexistence operations among IEEE 802.22b WRAN cells shall follow the top-level procedure illustrated in Figure 101 and described as follows:

1) The MR-BS of an IEEE 802.22b WRAN cell is powered on.
2) The MR-BS performs network discovery, which includes discovering
   - TV channel occupancies of the neighboring IEEE 802.22b WRAN cells
   - Self-coexistence window (SCW) reservations of the neighboring IEEE 802.22b WRAN cells
   - Frame reservation patterns of the neighboring IEEE 802.22b WRAN cells on specific channels (this information can be obtained from the received CBP packets)
3) The MR-BS performs channel acquisition based on the Spectrum Etiquette algorithm (as described in 7.20.3.1).
4) If the MR-BS successfully acquires a channel, it goes to the normal mode of data service operations on the acquired channel [as described in step 5) below]. If the MR-BS fails to acquire any empty channel, it selects a channel occupied by one or more other WRAN cells and identifies whether the potential interference comes directly from the other MR-BSs or from the CPEs belonging to the other WRAN cells, or both. If it comes only from the other MR-BSs, the new MR-BS initiates the DS/US Split adjustment mechanism [i.e., skips step 5) and goes to step 6)]. If the potential interference comes from the CPEs, it performs the Inter-WRAN On-demand Frame Contention operations on the selected channel by accessing a contention-based SCW (see 7.20.1.2) [i.e., skips step 5) and step 6) and goes to step 7)]. Note that since the new MR-BS arriving on the channel does not have a frame for itself yet, it cannot involve its CPEs in this initial contention process. Only CBP bursts transmitted directly from the new MR-BS will be able to support the frame contention process in this initial phase. As a result, the process may go initially to step 6) but then move to step 7) when the CPEs belonging to the new WRAN cell start to operate and report potential interference through their CBP bursts.
5) The MR-BS enters the normal mode of data service operations (see 7.3). During the normal service operations, the MR-BS may receive external demands (received from other WRAN cells) for sharing its occupied data frames on the operating channel. When this occurs and when the MR-BS cannot find another empty channel for its operation through the Spectrum Etiquette algorithm, the MR-BS performs the Inter-WRAN On-demand Frame Contention operations on its operating channel [as described in step 6)]. If an empty channel is found, then the MR-BS moves its cell to this new channel and enters the normal mode of data service operations (see 7.3).

6) The MR-BS performs the DS/US Split adjustment mechanism using the relevant parameter exchange carried by the SCH or Extended Frame Control Header (see Table B1) and/or by the CBP burst received directly from the other MR-BSs. Once it has acquired information on the Current DS/US Split, Claimed DS/US Split and the DS/US Change Offset, it applies the same basic algorithm as used for Quiet Period Scheduling described in Table 184 and transmits its updated parameters to the other MR-BSs so that they do the same and converge towards a common DS/US Split, which will vary depending on the compound traffic requirements for the MR-BSs involved. The adjustment of the DS/US Split through this distributed negotiation process, based on the fact that all MR-BSs have their frames aligned (see 9.10), will allow the concurrent use of the same frames by these MR-BSs while avoiding interference caused by a MR-BS that would be still transmitting while the other MR-BSs have started their upstream subframe and try to receive signals from their CPEs. Note that this will cover the cases where MR-BSs would interfere with each other even though there is no CPE being interfered (i.e., no CPE in the overlap area). There may also be cases where CPEs will receive interference from various MR-BSs while these MR-BSs do not interfere with each other as a result of clever MR-BS antenna installation that will block the signal path between the MR-BSs. The normal case will however be when both MR-BSs and CPEs are interfered with. For these two latter cases, step 7) will be needed to distribute the frames to the various MR-BSs and, since there would not be concurrent use of these frames, there is then no longer a need to synchronize the DS/US split in these cases.

7) The MR-BS performs the On-demand Frame Contention operations with a neighboring WRAN cell on the selected channel, and then goes to the self-coexistence mode of data services operations (as described in step 8). A neighboring WRAN cell can contend for some of the frames used by the current MR-BS as long as it occupies a number of frames that is larger that the minimum stated in variable Frame_Contention_Min (see Table 274). The required message flow and the On-Demand Frame Contention Protocol are described in 7.20.3.2.

8) The MR-BS enters the self-coexistence mode of data services operations (see 7.3). During the self-coexistence mode of data service operations, the MR-BS may receive either internal demands (received from the inside of the MR-BS's own cell) for additional spectrum resources, or external demands (received from other WRAN cells) for sharing its occupied frames on the operating channel. When either of these events occurs, the MR-BS re-initiates the spectrum acquisition process starting from step 3) (Spectrum Etiquette for channel acquisition).

7.20.4.2 CBP-based Neighboring Network Discovery

During network entry and initialization and before any data transmission takes place, the MR-BS and CPE shall perform a network discovery procedure by scanning the wireless medium for CBP packets, SCH, FCH , or DRZ-FCH. This discovery procedure is part of the MR-BS and CPE initialization procedures described in 7.14.

During normal operation, the MR-BS and CPEs can discover other nearby IEEE 802.22b cells by listening to the medium on the look out for CBP packets from other cells and, possibly, SCH, FCH or DRZ-FCH on different channels. This can be accomplished through the scheduling of the Coexistence UIUC = 1 for passive mode SCW. If a CBP packet, SCH, or FCH is received by the CPE, which is managed by the MR-BS, it shall package that information and transport it to its MR-BS (see Table 172). If a CBP packet or DRZ-FCH is received by the CPE, which is managed by the distributed scheduling R-CPE, it shall package that information and transport it to its distributed scheduling R-CPE.

7.20.4.2.1 Discovery with SCW

The MR-BS can discover other WRAN cells by scheduling SCWs in passive mode, during which, it may request one or more of its CPEs to listen to the current operating channel to look for CBP packets from other WRANs or to listen to other channels for CBP packets, SCH, FCH or DRZ-FCH transmissions from other MR-BSs or CPEs associated with other MR-BSs.

7.21 Quiet periods and sensing

7.21.1 Two-stage sensing mechanism and quiet period management

7.21.2 Synchronization of overlapping quiet periods

Change the paragraph as follows:

Hence, BSs shall synchronize their quiet periods with other nearby BSs/MR-BSs. This is done using the fields available in the SCH (see Table 1) or Extended Frame Control Header (see Table B1) that are used to schedule quiet periods for intra-frame (see 7.21.1.1) and inter-frame sensing (see 7.21.1.2), and which are also carried in CBP packets (see 7.6.1.3.1). The BS/MR-BS shall be responsible for setting these fields whenever transmitting a SCH or an Extended Frame Control Header. These QP scheduling fields are sent in the following three sets of parameters in a self-coexistence situation:

7.21.2.1 Intra-frame quiet period synchronization

Change the paragraph as follows:

The “current” set of intra-frame quiet period parameters is used by the BS/MR-BS to indicate to its CPEs the quiet periods that are currently scheduled. Before becoming “current,” this set of QP scheduling parameters has to be confirmed by all coexisting WRAN cells through the CBP mechanism following a negotiation among these WRAN cells. The “claimed” set of intra-frame quiet period parameters is used by each BS/MR-BS to announce its new scheduling requirement for quiet periods considering the performance of the sensing techniques used by its CPEs, i.e., the sensing time needed to meet the required sensing threshold. This “claimed” set is broadcast by the SCH or the Extended Frame Control Header and retransmitted to the other coexisting WRAN cells by the CBP mechanism so that negotiation can take place to arrive at a common quiet period schedule that meets the maximum QP requirement while minimizing the overhead by reducing the non-concurrent quiet periods as much as possible. This “claimed” quiet period schedule, once it has become common to all coexisting WRAN cells can then be scheduled to become the “current” quiet period parameter set after sufficient time is given for the negotiation to cover for inter-cell propagation.

Each BS/MR-BS sends its claim to other coexisting BSs/MR-BSs through the SCH or the Extended Frame Control Header, which is then carried by the CBP mechanism. Each BS/MR-BS that receives a new “claim” shall compare it to its own claim and either replace the incoming claim by its larger claim for the QP repetition rate (i.e., number of 1’s in the bitmap/cycle length) and/or QP duration or keep it as is if its own claim is smaller. If its own claim is larger and the updating results in a new claim that is larger than the “current” QP repetition rate and/or duration, the BS shall reset the Claimed Intra-frame Quiet Period Offset to the minimum number of frames required to make sure that all coexisting BSs have received the claim (e.g., 2 hops, that is 2 superframes or frames) before sending it in the SCH and relaying it through the CBP mechanism. If the new claim is smaller than the “current” scheduling, the Claimed QP Offset parameter is repeater unchanged and the incoming scheduling parameters are also repeated unchanged.

7.21.2.2 Inter-frame Quiet Period Synchronization

Change the paragraph as follows:

The BS/MR-BS that receives information about other collocated IEEE 802.22 cells (either directly or reported through CPEs) shall synchronize with all quiet periods scheduled by the other cells for the inter-frame QP schedule. To synchronize inter-frame sensing quiet periods, the BS uses the information contained in the SCH or the Extended Frame Control Header, but in addition to that, the BS shall apply a random mechanism to decide whether to change its quiet period schedule. This mechanism will considerably mitigate the ping-pong effect and it is based on the following rule:

For example, consider that BS 1 received information on the SCH or the Extended Frame Control Header transmitted by a collocated BS 2. In this case, BS 1 shall modify its inter-frame quiet period schedule in order to synchronize with that of BS 2 if the Inter-frame Quiet Period Offset of BS1 is larger than that of BS2. If this rule is validated, BS 1 can proceed with the synchronization of its quiet period with that of BS 2. To this end, BS 1 shall schedule the change in its quiet period to take place N frames away, where N = rand(0, Q_{Thresh}) and rand(a, b) is a function that returns an integer number t, where $a \leq t < b$, and Q_{Thresh} is defined in units of superframe. If up until N superframes later BS 1 does not receive any more information regarding the next quiet period of BS 2, it shall proceed with its quiet period change to achieve synchronization. This is done by modifying the values of the Inter-frame Quiet Period Offset and Duration in the SCH when initiating the new superframe, or by transmitting an updated CHQ-REQ command.

7.21.3 CPE report

Insert new subclauses after 7.21.3:

7.21.4 Quiet periods and sensing for a relay network

7.21.4.1 Quiet period synchronization for a MR-BS's cell

For Quiet period synchronization for an MR-BS's cell containing S-CPEs and R-CPEs as shown in Figure AJ1, the MR-BS can schedule the quiet periods either in the explicit mode, which is done through the use of CHQ-REQ MAC message as described in 7.7.17.3, or in the implicit mode using the sensing related fields in the SCH on PHY Mode 1, or the Extended Frame Control Header on PHY Mode 2.

Quiet period allocation shall follow the same mechanisms described in 7.21.1.

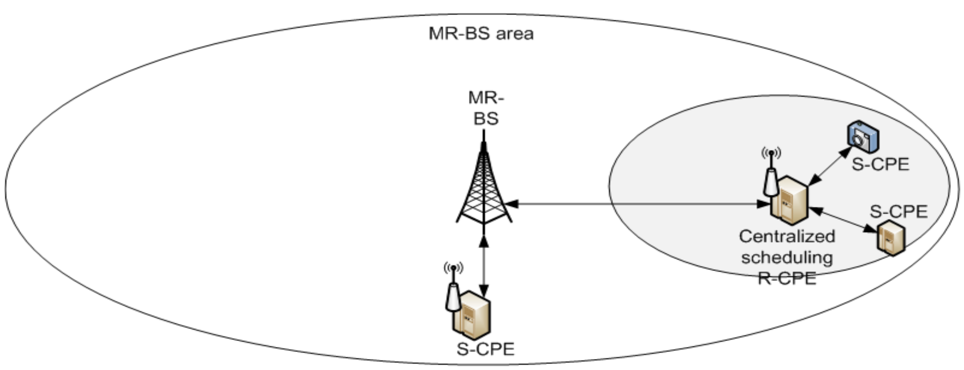

Figure AJ1—Quiet period synchronization within a MR-BS's cell

7.21.4.2 Quiet period synchronization for a local network

The Quiet periods shall be synchronized at all CPEs within a 802.22b network. Some S-CPEs located in a local cell, which are managed by a distributed scheduling R-CPE, may not be synchronized by the Quiet period scheduling information transmitted from an MR-BS due to the outside of the MR-BS's cell as shown in Figure AK1. Instead of the MR-BS, the distributed scheduling R-CPE shall transmit the Quiet period scheduling information transmitted from an MR-BS to the S-CPE within a local cell.

In the implicit quiet period scheduling, when a distributed scheduling R-CPE receives a SCH or an Extended Frame Control Header from the MR-BS, the distributed scheduling R-CPE shall send the SCH or the Extended Frame Control Header followed by DRZ-FCH to synchronize quiet period in a local cell.

In the explicit quiet period scheduling, the MR-BS uses the CHQ-REQ MAC message described in 7.7.17.3 to advertise the intra-frame sensing schedule and all the relevant parameters for sensing. When the distributed scheduling R-CPE receives CHQ-REQ MAC message from the MR-BS, it shall send CHQ-REQ MAC message to the CPEs within a local cell. This explicit mode should not be used in a self-coexistence operation since the quiet period scheduling information may not be made available to the other WRAN systems operating in the area. Only the implicit mode should be used in a self-coexistence situation.

Quiet period allocation shall follow the same mechanisms described in 7.21.1.

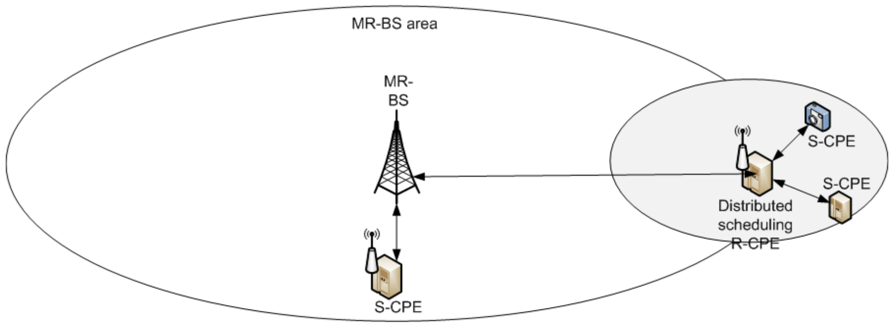

Figure AK1—Quiet period synchronization for a local network

7.22 Channel management

7.22.2 Scheduling of channel switching time

Insert new subclauses after 7.22.2:

7.22.3 Channel management on a relay network

Two modes of channel management supported by WRAN, which are an embedded mode and an explicit mode, are also supported in MR-WRAN.

In the embedded mode in MR-WRAN, the MR-BS shall transmit all IEs related to channel management to all CPEs in the cell. A distributed scheduling R-CPE shall transmit all channel management IEs received from the MR-BS to the CPEs managed by the distributed scheduling R-CPE.

In the explicit mode in MR-WRAN, the channel management messages could be sent by the MR-BS to the specific CPEs directly or relayed on the R-CPE such as a centralized scheduling R-CPE or a distributed scheduling R-CPE. When a R-CPE receives a channel management message not targeted to the R-CPE, the R-CPE shall relay the channel management message to the target CPE. In MR-WRAN, Figure AL1 depicts the message flow between MR-BS and CPE relayed on R-CPE when the ‘Confirmation Need’ field is set.

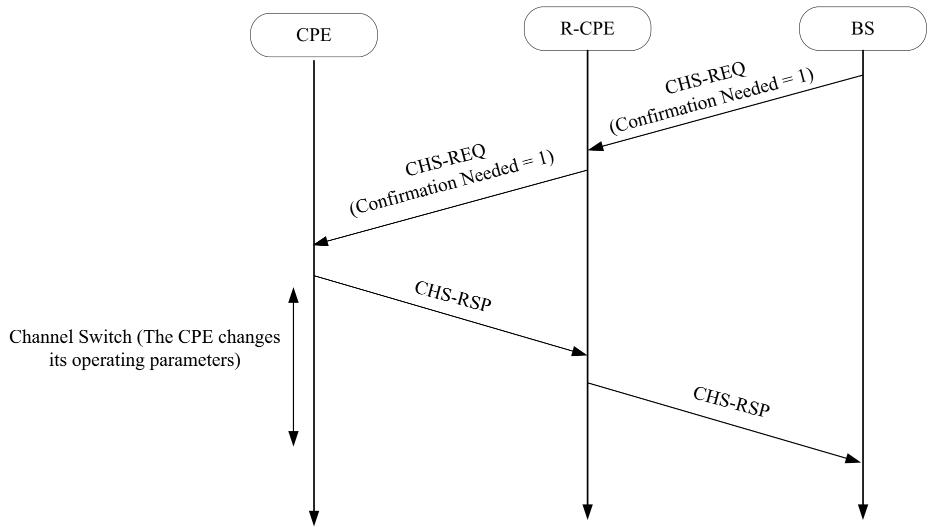

Figure AL1—Message flow between MR-BS and CPE relayed on R-CPE when confirmation is required

7.22.3.1 Initialization and Channel Sets Updating

In this subclause, procedures of channel list initialization and updating on relay are addressed.

In order to maintain the channel sets, an MR-BS maintains the following available channel sets: Operating, Backup, Candidate, Protected, Occupied, and Unclassified. Each S-CPE and centralized scheduling R-CPE within the MR-BS's cell maintains only the first three channel sets: Operating, Backup and Candidate. While, each distributed scheduling R-CPE maintains the same channel sets as the MR-BS's channel set. These individual sets have different update steps. For example, on the CPE side managed by the MR-BS, the Operating set is confirmed by every received SCH or FCH and the Backup and Candidate sets are updated after receiving the DCD. While, on the CPE side managed by the distributed scheduling R-CPE, the Operating set is confirmed by every received DRZ-FCH and the Backup and Candidate sets are updated after receiving the DCD in DRZ. After synchronization, the MR-BS should send an IPC-UPD message to the CPE to update the set of channels prohibited from incumbent operation for the newly connected CPE to allow skipping these channels to speed up the sensing process. These relations are summarized in Table AR1 and Table AS1 In the case of the MR-BS, channel sets are updated after each quiet period either at a periodic interval or aperiodic intervals. The MR-BS shall send all channel sets to the distributed scheduling R-CPE.

Table AR1—Update channel set information in CPE

Message	Field	Information
SCH	BS_ID	Operating channel on which the SCH is received on PHY mode 1
FCH	BS_ID	Operating channel on which the SCH is received on PHY mode 2

Table AR1—Update channel set information in CPE

Message	Field	Information
DCD	Number for Backup channels	Number of backup channels
	Backup and candidate channel list	List of backup and candidate channels
IPC-UPD	Incumbent Prohibited Channels Update	Channels that cannot carry incumbent signals since their operation is prohibited (e.g., channel 37 in the USA) and thus do not need to be sensed for the

Table AS1—Update channel set information in CPE for DRZ

Message	Field	Information
DRZ-FCH	BS_ID	Operating channel on which the DRZ-FCH is received
DCD	Number for Backup channels	Number of backup channels
	Backup and candidate channel list	List of backup and candidate channels
IPC-UPD	Incumbent Prohibited Channels Update	Channels that cannot carry incumbent signals since their operation is prohibited (e.g., channel 37 in the USA) and thus do not need to be sensed for the

When a CPE turns on, it scans the channels to identify the available WRAN operations and proceeds with the selection of one of these services (see 10.3.2). Such selection identifies the operating channel. As part of the CPE initialization, the list of backup and candidate channels is sent in the DCD message by the MR-BS or the distributed scheduling R-CPE. This procedure is closely related with obtaining downlink parameters procedure (see 7.14.2). After association of a new CPE, the MR-BS or the distributed scheduling R-CPE shall send the IPC-UPD message to indicate the list of channels prohibited from incumbent operation to the CPE so that it can skip incumbent sensing on these channels. Channel sets in the CPE are updated after periodically receiving the DCD message. In the case of the MR-BS, if channel sets are changed as a result of BLM-REP messages, the MR-BS sends the backup and candidate channel list in its DCD message. When the distributed scheduling R-CPE receives the updated channel list from the MR-BS, the distributed scheduling R-CPE sends the updated backup and candidate channl list in its DCD message in DRZ to the CPE.

7.22.3.2 Scheduling of channel switching time

When the MR-BS decides to switch channels during normal operation, it shall execute the following procedure to determine when to schedule the channel switching operation.

— The MR-BS selects the first backup channel from its backup/candidate channel list, it shall select a waiting time T46 to make sure that all its CPEs are prepared for the channel switch. The value of T46 is a configuration parameter that could be set by the management interface. The first requirement is that the value of T46 shall be smaller or equal to the maximum allowed channel moving time and the second requirement is that is long enough for the CPEs to recover from an incumbent detection.

— Then, the MR BS schedules the channel switch using the channel management procedure described in 7.19.5.

— When the distributed scheduling R-CPE receives channel switch requirement from the MR-BS, the distributed scheduling R-CPE shall make sure that all its CPEs in a local cell are prepared for the channel switch within the available switching time (Switch Count 7.7.17.1), which will be transmitted by the MR-BS.

7.23 Synchronization of the IEEE 802.22 base stations and IEEE 802.22b base stations

Change the first paragraph of 7.23:

The BSs and MR-BSs on PHY Mode 1 shall synchronize the absolute local start time of their superframe period, to the start of every minute referenced to UTC to a tolerance of less than or equal to ±2 µs. The MR-BS on PHY Mode 2 shall synchronize the absolute local start time of their frame period, to the start of every minute referenced to UTC to a tolerance of less than or equal to ±2 µs.

Insert new clause after 7.23:

7.24 Multi-channel operation

This clause describes the multi-channel operation supported by the IEEE Std. 802.22b, which is required to support enhanced broadband services and monitoring applications that require high data throughput. In the IEEE Std. 802.22-2011, single channel operation is supported as shown in Figure AM1 with maximum date rate of 22.69 Mbps. In Figure AM1, each CPE (CPE 1~CPE 5) is using the operating channel (f1) to communicate within the service area of BS where the operating channel (f1) is assigned by the spectrum manager using the available channel list. In the IEEE Std. 802.22-2011, even though there may be several available channels exist in the list, due to the constraint of the single channel operation of IEEE Std. 802.22-2011, those available channels cannot be utilized effectively since multi-channel operation is not supported.

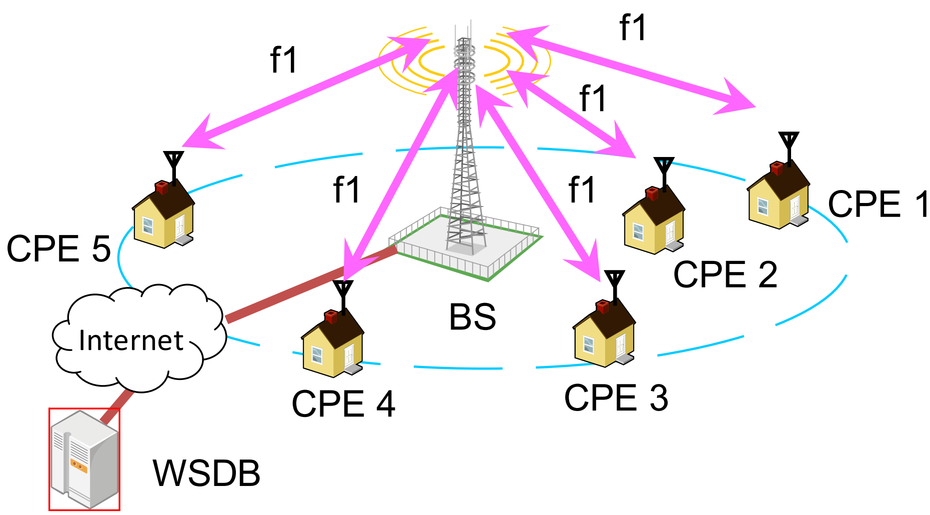

Figure AM1—Example of IEEE Std. 802.22-2011 deployment configuration (Single channel operation)

The IEEE Std. 802.22b supports aggregate data rates greater than the maximum data rate supported by the IEEE Std. 802.22-2011 in order to extend its regional area broadband services to a broader range of applications such as real-time and near real-time monitoring, emergency broadband services, remote medical services, etc. which requires higher data rates. Therefore, multi-channel operation shall be considered as a means to achieve throughput greater than the maximum throughput supported by the IEEE Std. 802.22-2011.

The examples of multi-channel operation deployment configuration are shown in Figure AN1 and Figure AO1 respectively. In Figure AN1, it is assumed that there are 2 available operating channels within the service area of the BS. In this example, multi-channel operation on BS is illustrated where only the BS is capable of receiving and transmitting two or more operating channels and responsible to assign the operating channel to the associated CPEs within it's service area. By performing the multi-channel operation on BS, the BS can utilize the available operating channels by distributing the operating channels among the associated CPEs. The multi-channel operation on BS can improve the individual CPE's throughput by decreasing the total number of associated CPEs per operating channel. In Figure AN1, CPE 1 and CPE 2 are assigned to the operating channel (f1) to communicate with the BS while CPE 3, CPE 4 and CPE 5 are assigned to the operating channel (f2) to communicate with the BS. In this example, the total number of associated CPEs assigned per operating channel can be reduce to more than 40% compare to the single channel operation situation in Figure AM1

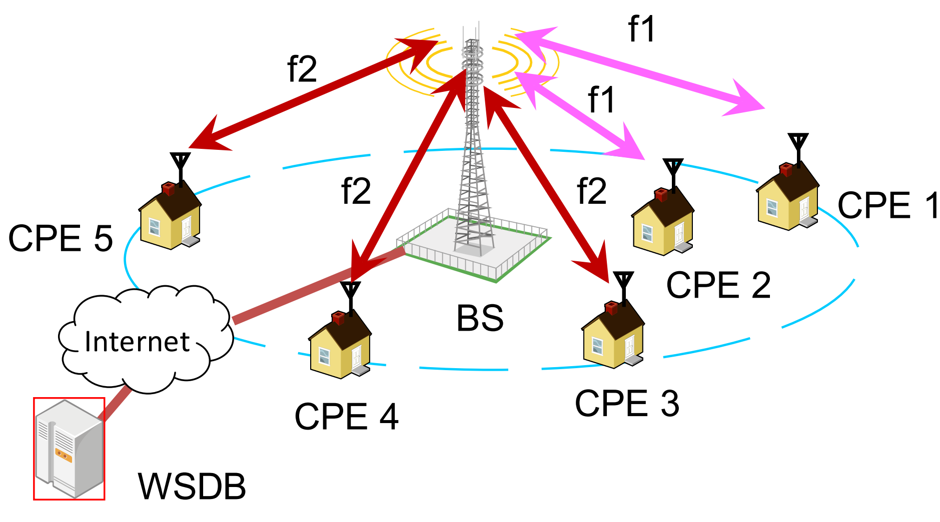

Figure AN1—Example of multi-channel operation deployment configuration (Multi-channel operation on BS)

In Figure AO1, it is assumed that there are 5 available operating channels within the service area of the BS. In this example, multi-channel operation on BS and CPEs is illustrated where both BS and associated CPEs are capable of receiving and transmitting two or more operating channels. BS is responsible to assign the operating channel to the associated CPEs within the service area for the utilization of available operating channels. In Figure AO1, CPE 1 is assigned to the operating channels (f1, f2, f3) to communicate with the BS while CPE 2 is assigned to the operating channels (f4, f5) to communicate with the BS. In this example, the BS can improve the individual CPE's throughput by increasing the number of operating channels assigned to the associated CPEs.

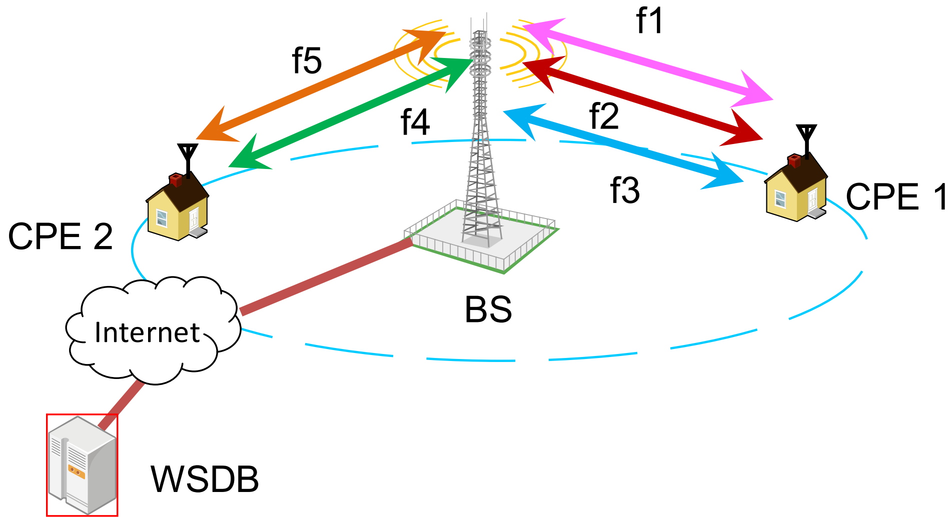

Figure AO1—Example of multi-channel operation deployment configuration (Multi-channel operation on BS and CPE)

7.24.1 Channel allocation manager

The channel allocation manager (CAM) shown in Figure AP1 is responsible for the basic multi-channel operations such as add new operating channel operation which is described in 7.24.1.1, stop operating channel which is described in 7.24.1.3 and switch operating channel which is described in 7.24.1.4.

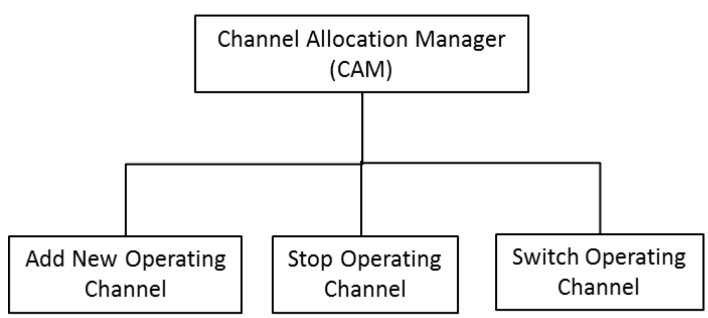

Figure AP1—Channel allocation manager

A channel allocation manager is needed on the IEEE 802.22b devices (BS and CPEs) to perform multi-channel operations which are described in 7.24.1.1, 7.24.1.3 and 7.24.1.4.

In 7.24.1.1, detailed operation flow of add new operating channel is discussed. The add new operating channel function is responsible for allocating new operating channel to each available channel transceiver unit (CHU) of the IEEE 802.22b devices.

In 7.24.1.3, detailed operation flow of stop operating channel is discussed. The stop operating channel function is responsible for stopping the operating channel of the specific CHU of the IEEE 802.22b devices.

In 7.24.1.4, detailed operation flow of switch operating channel is discussed. The switch operating channel function is responsible for switching the operating channel of the specific CHU of the IEEE 802.22b devices.

A channel transceiver unit (CHU) is defined as a transceiver unit for a specific channel operation which is consists of a MAC and a PHY.

7.24.1.1 Add new operating channel operation

When the BS is ready to operate under the multi-channel operation, the following procedure of adding new operating channel is performed on both BS and CPE which have the capability of receiving and transmitting two or more operating channels.

The add new operating channel operation procedure shall consist of the following steps:

1) BS-CAM selects a specific BS-CHU.
2) BS-CAM commences operation request.
3) BS-CHU commences operation acknowledgment.
4) BS-CAM sends management information notification to BS-CHU.
5) BS-CHU memorizes management information.
6) BS-CHU performs frequency setting.
7) BS-CHU performs synchronization.
8) BS-CHU sends operation preparation completed notification to BS-CAM.
9) BS-CHU broadcasts SCH.
10) BS-CAM checks unused BS-CHU.
11) CPE-CAM selects a specific CPE-CHU.
12) CPE-CAM sends BS search command (All / specific channel) to the specific CPE-CHU.
13) CPE-CHU performs BS search.
14) CPE-CHU sends BS detected notification to CPE-CAM.
15) CPE-CAM determines other operating CPE-CHU.
16) CPE-CAM performs BSID matching.
17) CPE-CAM sends BSID mismatch notification to CPE-CHU.
18) CPE-CAM sends proceed notification to CPE-CHU.
19) CPE-CHU performs synchronization.
20) CPE-CHU sends synchronization completed notification to CPE-CAM.
21) CPE-CAM checks unused CPE-CHU.
22) CPE-CAM sends registration request to CPE management unit.
23) CPE management unit sends registration completed notification to CPE-CAM.

The add new operating channel operation flow is shown in Figure AQ1.

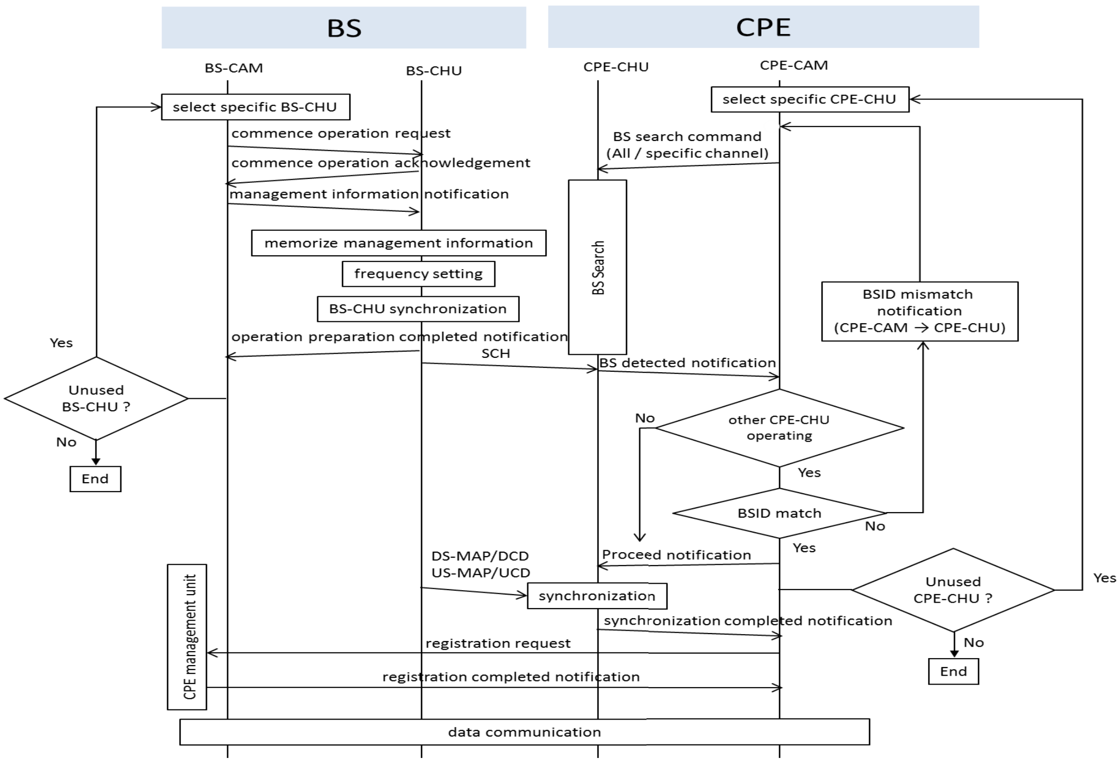

Figure AQ1—Operation flow for adding new operating channel

7.24.1.1.1 BS-CAM selects a specific BS-CHU

The BS channel allocation manager (BS-CAM) shall select specific BS channel transceiver unit (BS-CHU) which is the target of add new operating channel operation. The BS-CAM shall select the BS-CHU which is in the state of unused or unassigned currently and the hardware is corresponds to the new operating channel's frequency. The operating channel selection procedure may be included in this step.

7.24.1.1.2 BS-CAM commences operation request

The BS-CAM shall send a commence operation request to the selected BS-CHU. The commence operation request may include the various parameters in connection with the PHY such as channel center frequency and its offset, etc., and some part of MIB information such as software version information, etc.

7.24.1.1.3 BS-CHU commences operation acknowledgment

The BS-CHU shall send a commence operation acknowledgment to the BS-CAM. The commence operation acknowledgment may include the specific BS-CHU MIB information that is needed for BS-CAM such as device ID or serial number of the BS-CHU, etc. The BS-CHU shall responds with an error when the commence operation request is rejected due to the reasons such as mismatch of the software version, etc.

7.24.1.1.4 BS-CAM sends management information notification to BS-CHU

The BS-CAM shall send a management information notification to the BS-CHU. The management information notification may mainly include the MIB information necessary for BS-CHU which is maintained by BS-

CAM such as the ID to identify the connection between BS and CPE (carrier index which is associated with the physical or logical channel), etc. If the BS-CHU has a part of MAC layer function then the information on MIB which is used by MAC layer such as Station ID, MAC Address of BS, etc. shall be included.

7.24.1.1.5 BS-CHU memorizes management information

The BS-CHU shall memorize the management information notified by the BS-CAM after the management information notification. Some part of the memorized information (MIB information) shall be immediately reflected on the BS-CHU or reflected as the initial value of the transition state.

7.24.1.1.6 BS-CHU performs frequency setting

The BS-CHU shall perform the frequency setting procedure. The channel center frequency and its offset that was received in the commence operation request or management information notification shall be reflected in the local oscillator of BS-CHU.

7.24.1.1.7 BS-CHU performs synchronization

The BS-CHU shall perform the BS-CHU synchronization procedure. This procedure is intended for network synchronization to synchronize the superframe, frame and TDD timing of a number of BS in a wireless communication system. Basically, this procedure shall synchronize the superframe to the start of each minute of the UTC time obtained from the GPS, etc. As a result, all the operating BS-CHU shall be synchronized with each other.

7.24.1.1.8 BS-CHU sends operation preparation completed notification to BS-CAM

The BS-CHU shall send operation preparation completed notification to the BS-CAM. The BS-CHU shall send a response indicating an error when it fails on the mid-way of completing the operation preparation procedure.

7.24.1.1.9 BS-CHU broadcasts SCH

The BS-CHU shall periodically broadcast a radio frame which included the SCH information.

7.24.1.1.10 BS-CAM checks unused BS-CHU

The BS-CAM shall check whether there is any unused BS-CHU. If the unused BS-CHU exists, then the BS-CAM shall proceed to the select specific BS-CHU procedure.

7.24.1.1.11 CPE-CAM selects a specific CPE-CHU

The CPE channel allocation manager (CPE-CAM) shall select specific CPE channel transceiver unit (CPE-CHU) which is target of add new operating channel operation. The CPE-CAM shall select the CPE-CHU which is in the state of unused or unassigned. In many cases, this procedure is triggered by the BS lost condition occurs in CPE where the CPE-CHU is selected.

7.24.1.1.12 CPE-CAM sends BS search command (All / specific channel) to the specific CPE-CHU

The CPE-CAM shall send a BS search command (All / specific channel) to the selected CPE-CHU. The BS search command (All / specific channel) shall be performed by searching all the frequency channels that are corresponded by the selected CPE-CHU or by searching one or more specific frequency channels. The specific channel information shall be indicated by using the extended DCD message, newly defined management message, etc. to specify the BS operating channels that are not connected by any CPE or shall be estimated based on the backup channel information. To prevent overlapping with the other CPE-CHU channel, the channel which other CPE-CHU has already used shall not be searched. Moreover, the channel which other BS has already used that is identified by previous BS search command, etc. shall not be searched.

7.24.1.1.13 CPE-CHU performs BS search

The CPE-CHU shall perform the BS search command by attempting to detect the radio signal (preamble and SCH) from BS at the target frequency of BS search command.

7.24.1.1.14 CPE-CHU sends BS detected notification to CPE-CAM

The CPE-CHU shall send a BS detected notification to the CPE-CAM when it is able to detect the signal strength greater than or equal to a predetermined value that is defined in the BS search procedure. The BS detected notification shall include the BSID which is obtained by decoding the SCH information.

7.24.1.1.15 CPE-CAM determines other operating CPE-CHU

The CPE-CAM shall determine whether there is any other operating CPE-CHU (connection status with BS). If there is no other operating CPE-CHU at that time, then it does not correspond to add new operating channel procedure (multi-channel operation). The CPE-CHU shall proceed to the synchronization process similarly to the conventional IEEE Std. 802.22-2011.

7.24.1.1.16 CPE-CAM performs BSID matching

If there is other operating CPE-CHU detected at that time, the CPE-CAM shall determine the BSID of other operating CPE-CHU match with the BSID obtained by the CPE-CHU during BS detected notification.

7.24.1.1.17 CPE-CAM sends BSID mismatch notification to CPE-CHU

If the BSID mismatch occurred, then the BS-CAM shall send a BSID mismatch notification to the CPE-CHU and the CPE-CHU shall resume its BS search process with the rest of the targeted frequency or the BS-CAM shall send a specific target frequency of BS search command to the CPE-CHU.

7.24.1.1.18 CPE-CAM sends proceed notification to CPE-CHU

If the BSID match is confirmed, then the CPE-CAM shall send a proceed notification to the CPE-CHU to continue with the synchronization procedure.

7.24.1.1.19 CPE-CHU performs synchronization

The CPE-CHU shall continue with the synchronization procedure with the frequency which is detected in SCH. In addition to the original synchronization procedure such as detecting and decoding the FCH, DS-MAP, etc. to obtain the parameters of the DS, this procedure shall included the reception of UCD message process to obtain the parameters of the US, the ranging process to adjust the TDD timing, etc.

7.24.1.1.20 CPE-CHU sends synchronization completed notification to CPE-CAM

As a response to the proceed notification procedure, the CPE-CHU shall send a synchronization completed notification to the CPE-CAM. By referring to these notifications, the CPE-CAM can recognize the multi-channel operation when two or more CPE-CHUs are connected with the BS.

7.24.1.1.21 CPE-CAM checks unused CPE-CHU

The CPE-CAM shall check whether there is any unused CPE-CHU. If the unused CPE-CHU exists, then the

CPE-CAM shall proceed to the select specific CPE-CHU procedure.

7.24.1.1.22 CPE-CAM sends registration request to CPE management unit

The CPE-CAM shall send a registration request to the BS for CPE registration after completed the multi-channel operation capability. The registration request shall contain the information (carrier index, etc.) which can uniquely identify each channel used in the multi-channel operation. Some management messages may be exchanged only between the BS-CHU and CPE-CHU if necessary.

7.24.1.1.23 CPE management unit sends registration completed notification to CPE-CAM

The CPE management unit shall send a registration completed notification to the CPE-CAM.

7.24.1.2 Add new operating channel operation by using BS search command (specific channel)

As described in 7.24.1.1.12, the BS search command can be conducted in 2 modes (All / specific channel). In this sub clause, the detailed operation flow for add new operating channel operation by using BS search command in specific channel mode is shown here. In this operation flow, the BS-CHU and CPE-CHU shall have at least one operating channel to enable the exchange of management message between BS and CPE.

The operation flow for add new operating channel operation by using BS search command in specific channel mode shall consist of the following steps:

1) BS-CAM sends a aggregation information to BS-CHU1.
2) BS-CHU1 forwards a aggregation information to CPE-CHU1.
3) CPE-CHU1 forwards aggregation information to CPE-CAM.
4) BS-CAM selects a specific BS-CHU.
5) BS-CAM commences operation request.
6) BS-CHU2 commences operation acknowledgment.
7) BS-CAM sends management information notification to BS-CHU2.
8) BS-CHU2 memorizes management information.
9) BS-CHU2 performs frequency setting.
10) BS-CHU2 performs synchronization.
11) BS-CHU2 sends operation preparation completed notification to BS-CAM.
12) BS-CHU2 broadcasts SCH.
13) BS-CAM checks unused BS-CHU.
14) CPE-CAM selects a specific CPE-CHU.
15) CPE-CAM sends BS search command (All / specific channel) to the specific CPE-CHU2.
16) CPE-CHU2 performs BS search.
17) CPE-CHU2 sends BS detected notification to CPE-CAM.
18) CPE-CAM determines other operating CPE-CHU.
19) CPE-CAM performs BSID matching.
20) CPE-CAM sends BSID mismatch notification to CPE-CHU2.
21) CPE-CAM sends proceed notification to CPE-CHU2.
22) CPE-CHU2 performs synchronization.
23) CPE-CHU2 sends synchronization completed notification to CPE-CAM.
24) CPE-CAM checks unused CPE-CHU.

25) CPE-CAM sends registration request to CPE management unit.

26) CPE management unit sends registration completed notification to CPE-CAM.

The add new operating channel operation by using BS search command (specific channel) operation flow is shown in Figure AR1.

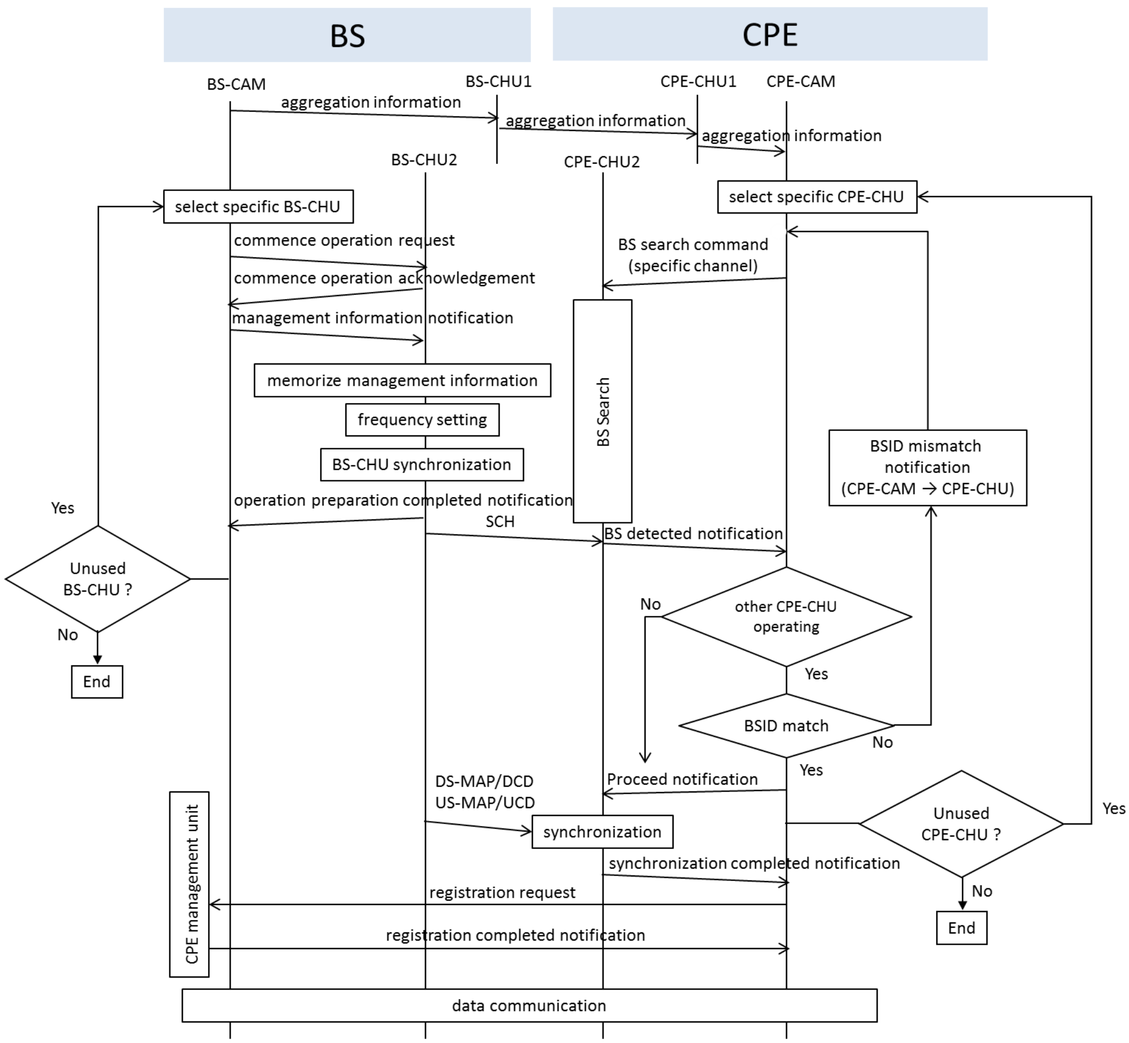

Figure AR1—Operation flow for adding new operating channel by using BS search command (specific channel)

7.24.1.2.1 BS-CAM sends an aggregation information to BS-CHU1

The BS-CAM shall send the aggregation information to the operating BS-CHU1 periodically during multi-channel operation and when to start a multi-channel operation.

7.24.1.2.2 BS-CHU1 forwards a aggregation information to CPE-CHU1

The BS-CHU1 shall forward the aggregation information to the CPE-CHU1 after receiving the information from BS-CAM.

7.24.1.2.3 CPE-CHU1 forwards aggregation information to CPE-CAM

The CPE-CHU1 shall forward the aggregation information to the CPE-CAM after receiving the information from BS-CHU1. The aggregation information shall be designed as a newly defined management message from BS-CAM. The detailed of the management message CAM-AIF is described in 7.7.29.1. The BS-CHU1 and CPE-CHU1 do not need to understand the content of the message when performing the forwarding process.

7.24.1.2.4 BS-CAM selects a specific BS-CHU

The BS-CAM shall select specific BS-CHU which is the target of add new operating channel operation. The BS-CAM shall select the BS-CHU which is in the state of unused or unassigned currently and the hardware is corresponds to the new operating channel's frequency. The operating channel selection procedure may be included in this step.

7.24.1.2.5 BS-CAM commences operation request

The BS-CAM shall send a commence operation request to the selected BS-CHU. The commence operation request may include the various parameters in connection with the PHY such as channel center frequency and its offset, etc., and some part of MIB information such as software version information, etc.

7.24.1.2.6 BS-CHU2 commences operation acknowledgment

The BS-CHU shall send a commence operation acknowledgment to the BS-CAM. The commence operation acknowledgment may include the specific BS-CHU MIB information that is needed for BS-CAM such as device ID or serial number of the BS-CHU, etc. The BS-CHU shall responds with an error when the commence operation request is rejected due to the reasons such as mismatch of the software version, etc.

7.24.1.2.7 BS-CAM sends management information notification to BS-CHU2

The BS-CAM shall send a management information notification to the BS-CHU. The management information notification may mainly include the MIB information necessary for BS-CHU which is maintained by BS-CAM such as the ID to identify the connection between BS and CPE (carrier index which is associated with the physical or logical channel), etc. If the BS-CHU has a part of MAC layer function then the information on MIB which is used by MAC layer such as Station ID, MAC Address of BS, etc. shall be included.

7.24.1.2.8 BS-CHU2 memorizes management information

The BS-CHU shall memorize the management information notified by the BS-CAM after the management information notification. Some part of the memorized information (MIB information) shall be immediately reflected on the BS-CHU or reflected as the initial value of the transition state.

7.24.1.2.9 BS-CHU2 performs frequency setting

The BS-CHU shall perform the frequency setting procedure. The channel center frequency and its offset that was received in the commence operation request or management information notification shall be reflected in the local oscillator of BS-CHU.

7.24.1.2.10 BS-CHU2 performs synchronization

The BS-CHU shall perform the BS-CHU synchronization procedure. This procedure is intended for network synchronization to synchronize the superframe, frame and TDD timing of a number of BS in a wireless communication system. Basically, this procedure shall synchronize the superframe to the start of each minute of the UTC time obtained from the GPS, etc. As a result, all the operating BS-CHU shall be synchronized with each other.

7.24.1.2.11 BS-CHU2 sends operation preparation completed notification to BS-CAM

The BS-CHU shall send operation preparation completed notification to the BS-CAM. The BS-CHU shall send a response indicating an error when it fails on the mid-way of completing the operation preparation procedure.

7.24.1.2.12 BS-CHU2 broadcasts SCH

The BS-CHU shall periodically broadcast a radio frame which included the SCH information.

7.24.1.2.13 BS-CAM checks unused BS-CHU

The BS-CAM shall check whether there is any unused BS-CHU. If the unused BS-CHU exists, then the BS-CAM shall proceed to the select specific BS-CHU procedure.

7.24.1.2.14 CPE-CAM selects a specific CPE-CHU

The CPE-CAM shall select specific CPE-CHU which is target of add new operating channel operation. The CPE-CAM shall select the CPE-CHU which is in the state of unused or unassigned. In many cases, this procedure is triggered by the BS lost condition occurs in CPE where the CPE-CHU is selected.

7.24.1.2.15 CPE-CAM sends BS search command (All / specific channel) to the specific CPE-CHU2

The CPE-CAM shall send a BS search command (specific channel) to the selected CPE-CHU. The BS search command (specific channel) shall be performed by searching one or more specific frequency channels. The specific channel information shall be indicated by using the extended DCD message, newly defined management message, etc. to specify the BS operating channels that are not connected by any CPE or shall be estimated based on the backup channel information. To prevent overlapping with the other CPE-CHU channel, the channel which other CPE-CHU has already used shall not be searched. Moreover, the channel which other BS has already used that is identified by previous BS search command, etc. shall not be searched.

7.24.1.2.16 CPE-CHU2 performs BS search

The CPE-CHU shall perform the BS search command by attempting to detect the radio signal (preamble and SCH) from BS at the target frequency of BS search command.

7.24.1.2.17 CPE-CHU2 sends BS detected notification to CPE-CAM

The CPE-CHU shall send a BS detected notification to the CPE-CAM when it is able to detect the signal strength greater than or equal to a predetermined value that is defined in the BS search procedure. The BS detected notification shall include the BSID which is obtained by decoding the SCH information.

7.24.1.2.18 CPE-CAM determines other operating CPE-CHU

The CPE-CAM shall determine whether there is any other operating CPE-CHU (connection status with BS). If there is no other operating CPE-CHU at that time, then it does not correspond to add new operating channel procedure (multi-channel operation). The CPE-CHU shall proceed to the synchronization process similarly to the conventional IEEE Std. 802.22-2011.

7.24.1.2.19 CPE-CAM performs BSID matching

If there is other operating CPE-CHU detected at that time, the CPE-CAM shall determine the BSID of other operating CPE-CHU match with the BSID obtained by the CPE-CHU during BS detected notification.

7.24.1.2.20 CPE-CAM sends BSID mismatch notification to CPE-CHU2

If the BSID mismatch occurred, then the BS-CAM shall send a BSID mismatch notification to the CPE-CHU and the CPE-CHU shall resume its BS search process with the rest of the targeted frequency or the BS-CAM shall send a specific target frequency of BS search command to the CPE-CHU.

7.24.1.2.21 CPE-CAM sends proceed notification to CPE-CHU2

If the BSID match is confirmed, then the CPE-CAM shall send a proceed notification to the CPE-CHU to continue with the synchronization procedure.

7.24.1.2.22 CPE-CHU2 performs synchronization

The CPE-CHU shall continue with the synchronization procedure with the frequency which is detected in SCH. In addition to the original synchronization procedure such as detecting and decoding the FCH, DS-MAP, etc. to obtain the parameters of the DS, this procedure shall included the reception of UCD message process to obtain the parameters of the US, the ranging process to adjust the TDD timing, etc.

7.24.1.2.23 CPE-CHU2 sends synchronization completed notification to CPE-CAM

As a response to the proceed notification procedure, the CPE-CHU shall send a synchronization completed notification to the CPE-CAM. By referring to these notifications, the CPE-CAM can recognize the multi-channel operation when two or more CPE-CHUs are connected with the BS.

7.24.1.2.24 CPE-CAM checks unused CPE-CHU

The CPE-CAM shall check whether there is any unused CPE-CHU. If the unused CPE-CHU exists, then the CPE-CAM shall proceed to the select specific CPE-CHU procedure.

7.24.1.2.25 CPE-CAM sends registration request to CPE management unit

The CPE-CAM shall send a registration request to the BS for CPE registration after completed the multi-channel operation capability. The registration request shall contain the information (carrier index, etc.) which can uniquely identify each channel used in the multi-channel operation. Some management messages may be exchanged only between the BS-CHU and CPE-CHU if necessary.

7.24.1.2.26 CPE management unit sends registration completed notification to CPE-CAM.

The CPE management unit shall send a registration completed notification to the CPE-CAM.

7.24.1.3 Stop operating channel operation

When the BS is operating under the multi-channel operation, the following procedure of stop operating channel is performed on both BS and CPE to stop the operating channel which is request by the BS.

The stop operating channel operation procedure shall consist of the following steps:

1) BS-CAM sends stop operation request to BS-CHU.
2) BS-CHU starts stop operation timer.

3) BS-CHU sends stop operation request acknowledgment to BS-CAM
4) BS-CHU sends stop operation request to CPE-CHU.
5) CPE-CHU starts stop operation timer.
6) CPE-CHU sends stop operation notification to CPE-CAM.
7) CPE-CAM sends stop operation approval/command to CPE-CHU.
8) CPE-CHU sends stop operation request acknowledgment to BS-CHU.
9) CPE-CHU checks stop operation timer expired and stops operation.
10) CPE-CHU sends stop operation completed notification to CPE-CAM.
11) BS-CHU checks stop operation timer expired and stops operation.
12) BS-CHU sends stop operation completed notification to CPE management unit.

The stop operating channel operation flow is shown in Figure AS1.

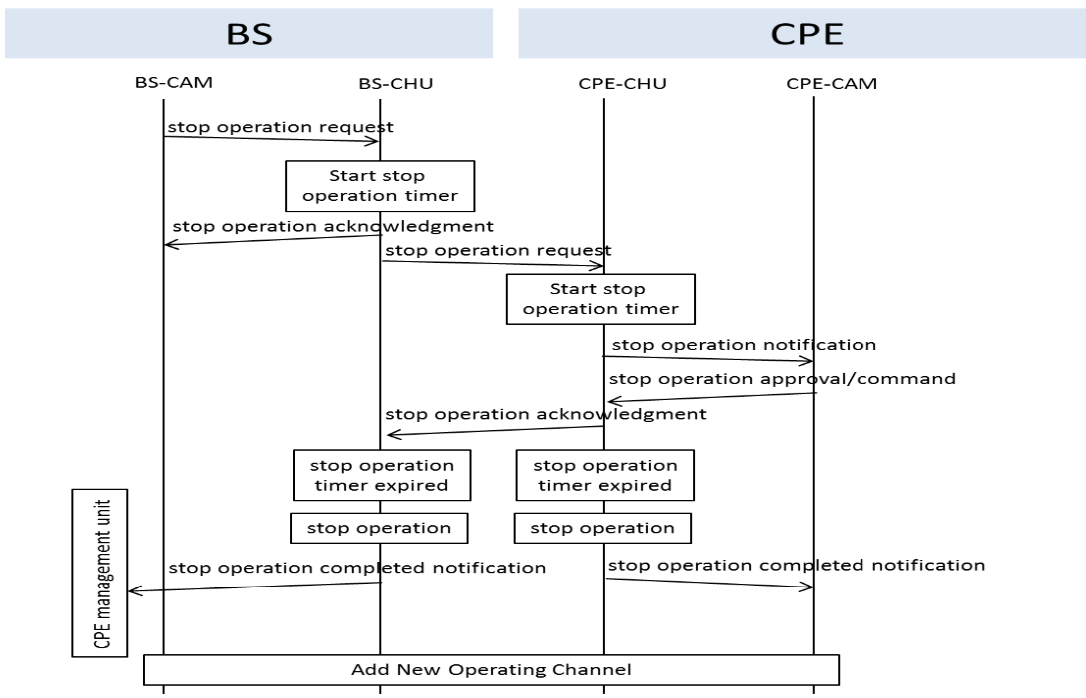

Figure AS1—Operation flow for stopping operating channel

7.24.1.3.1 BS-CAM sends stop operation request to BS-CHU

The BS-CAM shall send the stop operation request to the BS-CHU which is the target of stop operating channel operation.

7.24.1.3.2 BS-CHU starts stop operation timer

The BS-CHU shall start the stop operation timer after receiving the stop operation request from BS-CAM. The start of the stop operation timer shall determine the frame number where the operation is scheduled to stop.

7.24.1.3.3 BS-CHU sends stop operation request acknowledgment to BS-CAM

The BS-CHU shall send the stop operation request acknowledgement to the BS-CAM.

7.24.1.3.4 BS-CHU sends stop operation request to CPE-CHU

The BS-CHU shall send the stop operation request to the CPE-CHU by using the downstream transmission. The stop operation request can be send as a new defined management message. The detailed of the management message CAM-STP is described in 7.7.29.2.

7.24.1.3.5 CPE-CHU starts stop operation timer

Based on the information which specifies the target of the stop operation channel that can be obtained after receiving the stop operation request from the BS-CHU, the CPE-CHU shall confirm the target channel of the request. If the request is addressed to the CPE-CHU, then the CPE-CHU shall start the stop operation timer.

7.24.1.3.6 CPE-CHU sends stop operation notification to CPE-CAM

The CPE-CHU shall send the stop operation notification to the CPE-CAM.

7.24.1.3.7 CPE-CAM sends stop operation approval/command to CPE-CHU

The CPE-CAM shall send the stop operation approval/command to the CPE-CHU after the CPE-CAM is notified that the channel operation of the CPE-CHU will be stopped.

7.24.1.3.8 CPE-CHU sends stop operation request acknowledgment to BS-CHU

The CPE-CHU shall send the stop operation request acknowledgement to the BS-CHU after receiving the stop operation approval/command from the CPE-CAM. The stop operation acknowledgement can be send as a new defined management message through the upstream transmission. The detailed of the management message CAM-STP is described in 7.7.29.2.

7.24.1.3.9 CPE-CHU checks stop operation timer expired and stops operation

The CPE-CHU shall stop the operation when the stop operation timer is expired which means that it has reached the frame number that is set during the set stop operation timer procedure. The CPE-CHU shall stop all transmission and reception after the stop operation procedure is performed.

7.24.1.3.10 CPE-CHU sends stop operation completed notification to CPE-CAM

The CPE-CHU shall send the stop operation completed notification to the CPE-CAM after completed the stop operation procedure.

7.24.1.3.11 BS-CHU checks stop operation timer expired and stops operation

The BS-CHU shall stop the operation when the stop operation timer is expired and stop all the transmission and reception after the stop operation procedure is performed.

7.24.1.3.12 BS-CHU sends stop operation completed notification to CPE management unit.

The BS-CHU shall send the stop operation completed notification to the BS-CAM and CPE management unit after completed the stop operation procedure. The BS-CHU and CPE-CHU that has stopped their operation will be the target CHU for the add new operating channel procedure.

7.24.1.4 Switch operating channel operation

When the BS is operating under the multi-channel operation, the following procedure of switch operating channel is performed on both BS and CPE to switch the operating channel which is request by the BS.

The switch operating channel operation procedure shall consist of the following steps:

1) BS-CAM sends channel switch request to BS-CHU.
2) BS-CHU starts channel switch timer.
3) BS-CHU sends channel switch request acknowledgment to BS-CAM.
4) BS-CHU sends channel switch request to CPE-CHU.
5) CPE-CHU starts channel switch timer.
6) CPE-CHU sends channel switch notification to CPE-CAM.
7) CPE-CAM sends channel switch approval/command to CPE-CHU.
8) CPE-CHU sends channel switch request acknowledgment to BS-CHU.
9) BS-CHU checks channel switch timer expired and performs channel switch.
10) CPE-CHU checks channel switch timer expired and performs channel switch.
11) BS-CHU sends channel switch completed notification to BS-CAM.
12) BS-CHU broadcasts SCH.
13) BS-CHU sends DS-MAP/DCD/US-MAP/UCD to CPE-CHU.
14) CPE-CHU sends channel switch completed notification to CPE-CAM.
15) CPE-CHU sends channel switch completed notification to CPE management unit.

The switch operating channel operation flow is shown in Figure AT1.

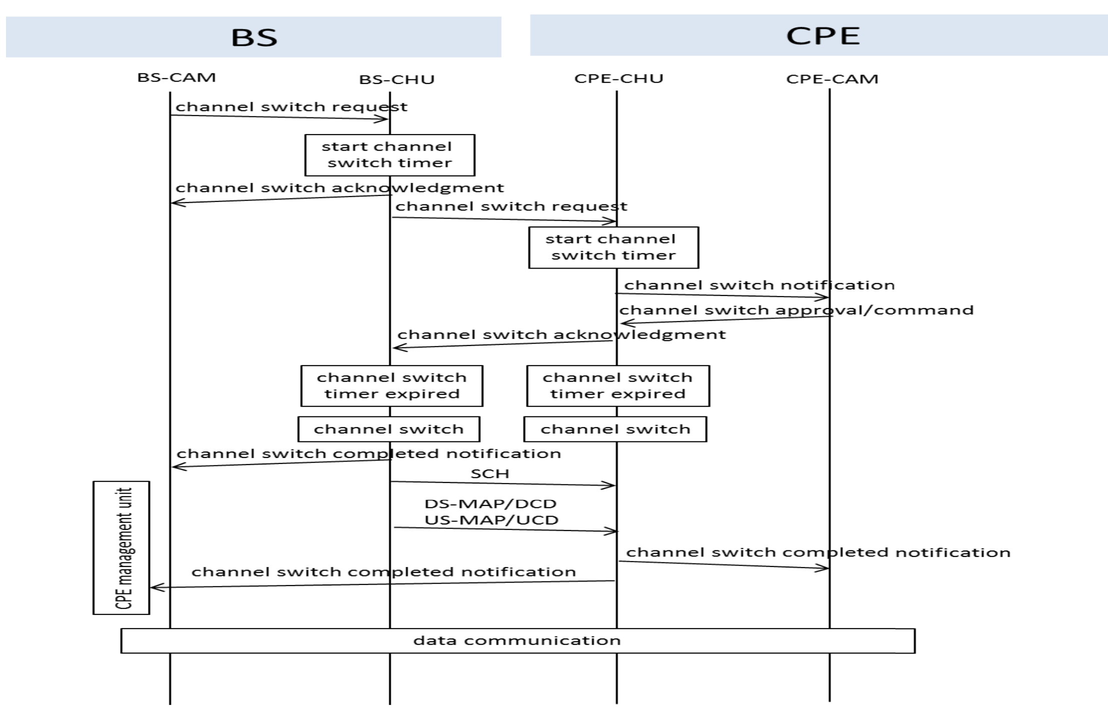

Figure AT1—Operation flow for switching operating channel

7.24.1.4.1 BS-CAM sends channel switch request to BS-CHU

The BS-CAM shall send the channel switch request to the BS-CHU which is the target of switch operating channel operation. The BS-CHU shall correspond to the requested switch operating channel's frequency.

7.24.1.4.2 BS-CHU starts channel switch timer

The BS-CHU shall start the channel switch timer after receiving the channel switch request from BS-CAM. The start of the channel switch timer shall determine the frame number where the new operating channel is scheduled to switch.

7.24.1.4.3 BS-CHU sends channel switch request acknowledgment to BS-CAM

The BS-CHU shall send the channel switch request acknowledgement to the BS-CAM.

7.24.1.4.4 BS-CHU sends channel switch request to CPE-CHU

The BS-CHU shall send the channel switch request to the CPE-CHU by using the downstream transmission. The channel switch request can be send as a new defined management message. The detailed of the management message CAM-SWH is described in 7.7.29.4. The management message shall be broadcasted to all the CPE and the CPE shall be able to receive and interpret the content of the management message.

7.24.1.4.5 CPE-CHU starts channel switch timer

The CPE-CHU shall start the channel switch timer after receiving the channel switch request from the BS-CHU.

7.24.1.4.6 CPE-CHU sends channel switch notification to CPE-CAM

The CPE-CHU shall send the channel switch notification to the CPE-CAM.

7.24.1.4.7 CPE-CAM sends channel switch approval/command to CPE-CHU

The CPE-CAM shall send the channel switch approval/command to the CPE-CHU after the CPE-CAM is notified that the operating channel of the CPE-CHU will be switched.

7.24.1.4.8 CPE-CHU sends channel switch request acknowledgment to BS-CHU

The CPE-CHU shall send the channel switch request acknowledgement to the BS-CHU after receiving the channel switch approval/command from the CPE-CAM. The channel switch request acknowledgement can be send as a new defined management message through the upstream transmission. The detailed of the management message CAM-SWH is described in 7.7.29.4.

7.24.1.4.9 BS-CHU checks channel switch timer expired and performs channel switch

The BS-CHU shall switch to a new operating channel when the channel switch timer is expired which means that it has reached the frame number that is set during the start channel switch timer procedure. The BS-CHU shall modify the operating parameters within the RTG period and shall change the frequency of the local oscillator in order to switch to a new operating channel. Since channel switch is performed due to the necessity of termination of operation on current channel in most of the cases, a channel switch is enforced even if the channel switch acknowledgement is not receive from neither one of the CPEs.

7.24.1.4.10 CPE-CHU checks channel switch timer expired and performs channel switch

The CPE-CHU shall switch to a new operating channel when the channel switch timer is expired.

7.24.1.4.11 BS-CHU sends channel switch completed notification to BS-CAM

The BS-CHU shall send the channel switch completed notification to the BS-CAM after completed the channel switch procedure. This shall indicate that the channel switch procedure at the physical layer of BS-CHU is completed (such as the frequency of the local oscillator of BS-CHU is locked to the new channel, etc.).

7.24.1.4.12 BS-CHU broadcasts SCH

The BS-CHU shall broadcast a radio frame which included the SCH information.

7.24.1.4.13 BS-CHU sends DS-MAP/DCD/US-MAP/UCD to CPE-CHU

The BS-CHU shall send the DS-MAP/DCD/US-MAP/UCD information to CPE-CHU for synchronization procedure.

7.24.1.4.14 CPE-CHU sends channel switch completed notification to CPE-CAM

The CPE-CHU shall send the channel switch completed notifiction to CPE-CAM when the frame containing SCH, etc. is received correctly. The channel switch completion notification shall indicate that the channel switch has been completed at the MAC layer.

7.24.1.4.15 CPE-CHU sends channel switch completed notification to CPE management unit

The CPE-CHU shall send the channel switch completed notification to the CPE management unit. The channel switch completed notification can be send as a new defined management message through the upstream transmission. The detailed of the management message CAM-SWH is described in 7.7.29.4. Upon receiving the management message, the CPE management unit in BS shall update the latest information of the CPEs.

7.24.2 Multi-channel operation at BS

This clause explain the operation flow of the BS's channel allocation manager (BS-CAM) for commencing the multi-channel operation. The operation flow of commencing multi-channel operation at BS is shown in Figure AU1. In order to perform the multi-channel allocation which is neccesary for multi-channel operation, three basic functions which are add new operating channel, stop operating channel and switch operating channel are newly defined. The detailed explanation of each function and it's operation flow are described in 7.24.1.1, 7.24.1.3 and 7.24.1.4.

In commencing multi-channel operation at BS, the BS-CAM shall play the key role to decide the operating channel and determine the implementation of either one of the 3 basic functions as shown in Figure AU1. The triggers for the BS-CAM to decide the operating channel are database access, BS sensing report, CPE sensing report and BS channel scheduling. The database access trigger shall referring to the database access result which concluded that there are changes in the available operating channels after accessing the whitespace database by the database access control in BS. The BS sensing report and CPE sensing report shall refer to the sensing report which concluded that there are changes in the available operating channels after performing the sensing process. These are triggers that caused by the changes in the available operating channels. The BS channel scheduling is the case where a particular operating channel is available under specific time scheduling by the BS.

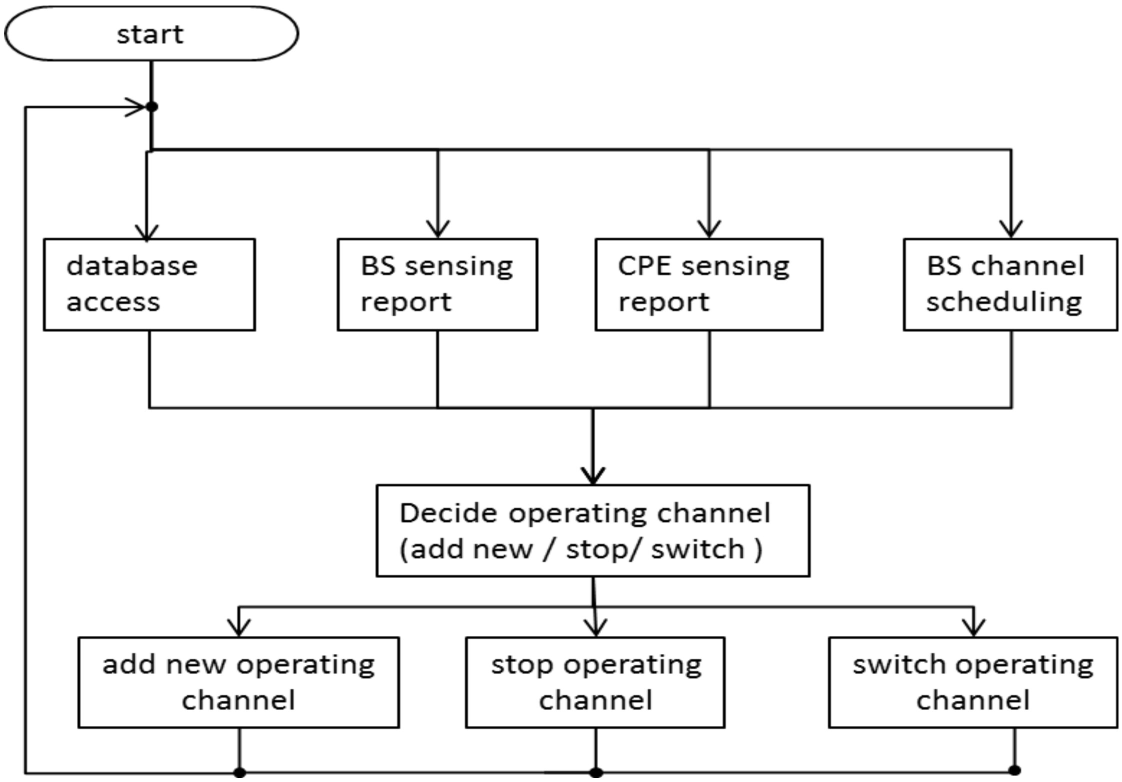

Figure AU1—Commence multi-channel operation at BS

7.24.3 Multi-channel operation at CPE

This clause explain the operation flow of the CPE's channel allocation manager (CPE-CAM) for commencing the multi-channel operation. The operation flow of commencing multi-channel operation at CPE is shown in Figure AV1. In order to perform the multi-channel allocation which is neccesary for multi-channel operation, the CPE-CAM also possess three basic functions which are add new operating channel, stop operating channel and switch operating channel. The detailed explanation of each function and it's operation flow are described in 7.24.1.1, 7.24.1.3 and 7.24.1.4.

In commencing multi-channel operation at CPE, most of the triggers of the CPE-CAM operation are resulted from the BS control messages. The triggers for the CPE-CAM to commence the multi-channel operation are BS control message, CPE incumbent sensing report, CPE channel scheduling and BS lost message.The BS control message including the switch operating channel and stop operating channel control messages. When the CPE-CAM received the switch operating channel control message from the BS, it shall proceed to the switch operating channel procedure and switch to the operating channel as stated in the switch operating channel control message. When the CPE-CAM received the stop operating channel control message from the BS, it shall proceed to the stop operating channel procedure and stop the operating channel as stated in the stop operating channel control message. Furthermore, when the CPE incumbent sensing report showed the detection of incumbent or the CPE channel scheduling is scheduled to stop the operating channel, it shall proceed to the stop operating channel procedure as well. The BS lost message which indicates the lost connection between a CPE-CHU and a BS or the CPE channel scheduling for adding a new operating channel shall proceed to the add new operating channel procedure.

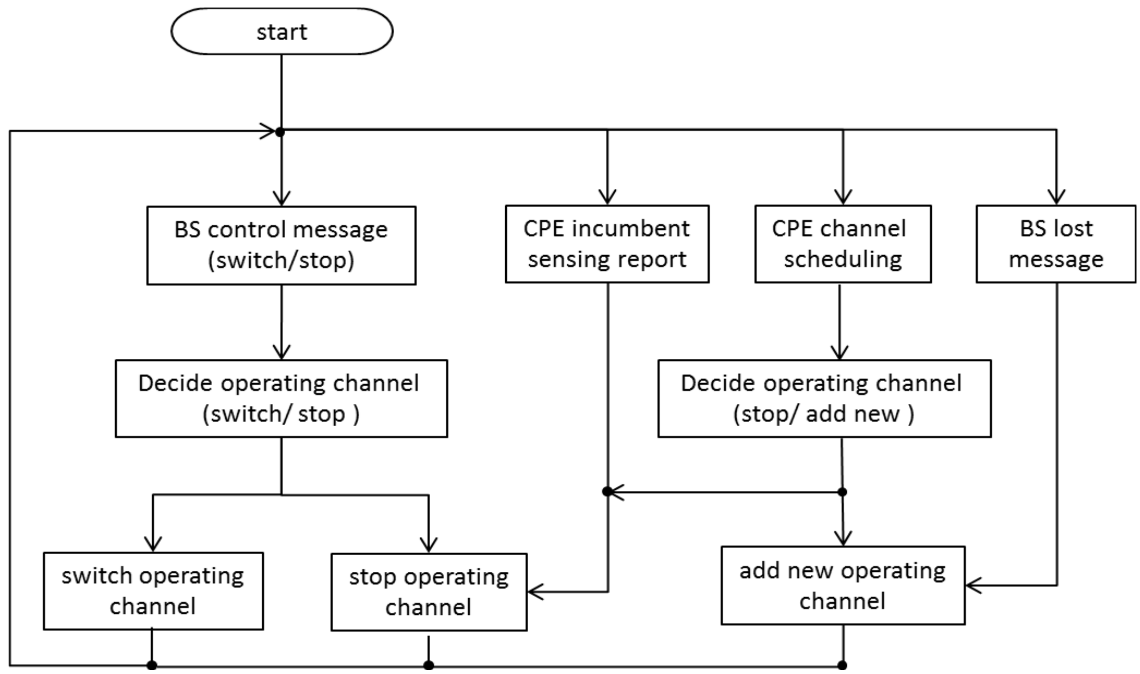

Figure AV1—Commence multi-channel operation at CPE

Insert new clause after 7.25:

7.25 Group Resource Allocation

A large number of CPEs (at least 2048 CPEs) may be connected to the BS. Among them, some CPEs have similar traffic pattern, such as, payload size, traffic period, and data rate (PHY mode), etc. It is a burden of MAP overhead to allocate the resources to all CPEs individually. The Group Resource Allocation (GRA) is very efficient for a group of CPEs communicating using a same PHY mode and with a fixed payload size. The MAP overhead is significantly reduced by allocating the resources to the Group using bitmap format.

The group is composed of one H-CPE and many L-CPEs. Within the group, H-CPE is a controller of a group consisting of many L-CPEs. The H-CPE capabilities include access to the database services, identification of the group, network entry with BS, etc. All the L-CPEs within the group are synchronized to the H-CPE.

There are two types of group: fixed group and mobile (or portable) group. The type of group is determined according to the mobility of H-CPE. The H-CPE within fixed group is fixed on the building, house, tower, etc. The H-CPE within mobile (or portable) group is mobile (or portable) on the vehicles, etc.

The BS configures the group resource allocation by using the Group Resource Allocation Configuration (GRA-CFG) message, as shown in Table AK1. The BS creates a new group, identifies the devices that are belonging to the group, and allocates the resources on a group basis. The GRA-CFG message includes the characteristics of group, such as Device Bitmap Size, Bitmap of Station ID, Group ID, Group Type, and Group Location. The group resource allocation configuration can be updated using the Group Resource Allocation Update (GRA-UPD) message, as shown in Table AL1. The BS uses GRA-UPD message to add a device to a group or delete a device from a group. The DS/US-MAP message defines the access to the downstream/upstream resources, as shown in Table 25 and Table 34, respectively. The format of a DS/US-MAP IEs is defined for the Individual Resource Allocation (IRA), as shown in Table 26 and Table 35, respectively. And the format of a DS/US-MAP GRA IEs is defined for the Group Resource Allocation (GRA), as shown in Table J1 and Table J1, respectively.

The backup and candidate channels can also be updated on a group basis using Backup and Candidate Channel List IE, as shown in Table 22. When Group Flag is set to 1, the backup and candidate channels are used locally within a group. Otherwise, when Group Flag is set to 0, the backup and candidate channels are used globally within a cell. The backup and candidate channels are selected using the mobility and the location of H-CPE. Same channel is selected as the backup (or candidate) channel between the fixed groups. But if the groups could overlap, the backup (or candidate) channel shall be different to avoid interference among groups. On the other hand, different channels are selected as the backup (or candidate) channel between the fixed and the mobile group or between the mobile groups. But if the groups could not overlap, the backup (or candidate) channel could be same for frequency reuse. The backup and candidate channel list of each group shall be updated according to the periodic monitoring which checks whether the groups could overlap each other or new group appears. Therefore, when mobile group moves into other group, or when new group or incumbent user appears within a cell, the BS and CPEs can reduce the signaling overhead and can prevent QoS degradation by avoiding frequent channel switching.

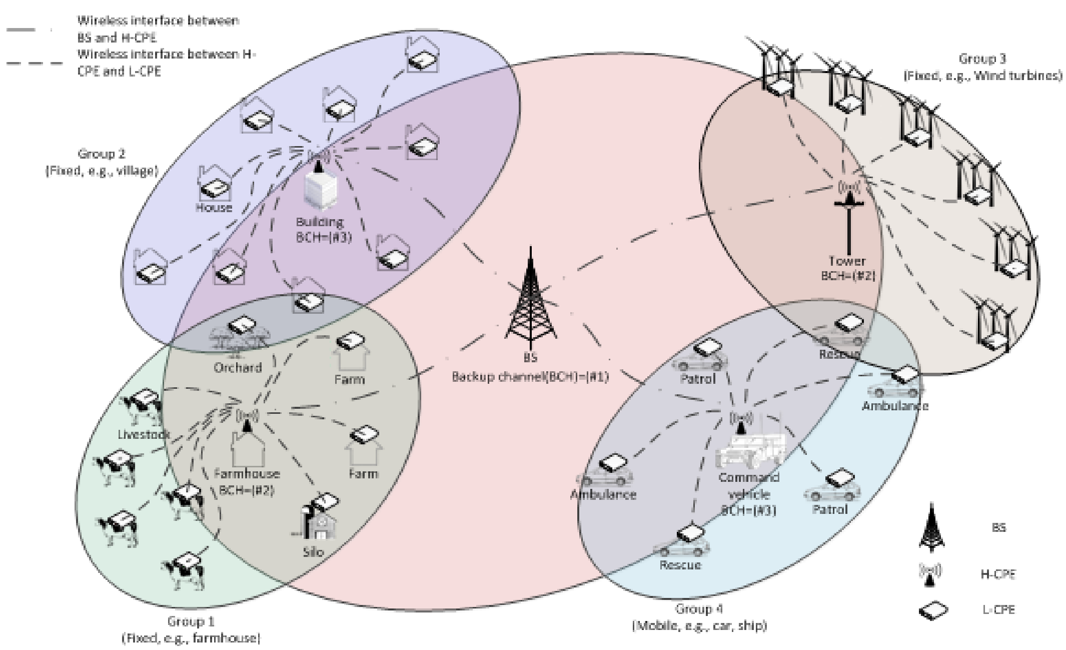

Figure AW1—Example of backup channel selection

Figure AW1 shows an example of how the backup channel is selected. There are three fixed groups and single mobile group. The H-CPE of fixed groups is installed at the fixed object, such as farmhouse, building, tower, etc. The H-CPE of mobile group is installed at the mobile or portable object, such as car, train, ship, etc. In a relationship between the group 1 and the group 2, there are two fixed groups which is overlapping each other, thus the BS may allocate different backup channels, for example, backup channel #2 and backup channel #3, to the group 1 and the group 2, respectively. In a relationship between the group 1 and the group 3, there are two fixed groups which is not overlapping each other, thus the BS may allocate same backup channel, for example, backup channel #2, to both the group 1 and the group 3. In a relationship between the group 3 and the group 4, there are fixed and mobile groups which is overlapping each other, thus the BS may allocate different backup channels, for example, backup channel #2 and backup channel #3, to the group 3 and the group 4, respectively. In a relationship between the group 2 and the group 4, there are fixed and mobile groups which is not overlapping each other, thus the BS may allocate same backup channel, for example, backup channel #3, to both the group 2 and the group 4.

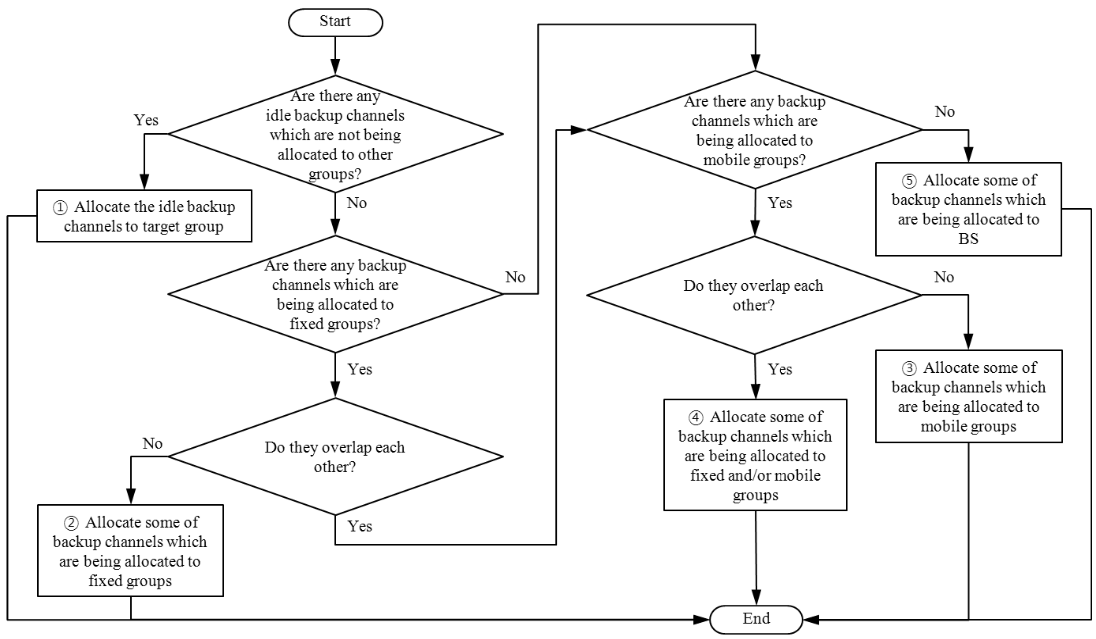

Figure AX1—Example of backup channel decision

Figure AX1 shows an example of how the backup channel is decided. When there are any idle backup channels which are not being allocated to other groups, the BS allocates the idle backup channels to the target group (1). When there are no idle backup channels to be allocated, the BS may first check if there exist any backup channels allocated to a fixed group. When there are any backup channels which are being allocated to fixed groups, and target group and fixed group do not overlap, the BS allocates the backup channels allocated to the fixed group, to the target group (2). A presence of a backup channel allocated to the fixed group may be first checked since a burden of changing the backup channels may exist when a state of a backup channel being currently allocated to a mobile group is changed to an unavailable backup channel, due to mobility of the mobile group, although it is determined that the allocated backup channel is available. When there are no backup channels which are being allocated to fixed groups, or when there are any backup channels which are being allocated to fixed groups but the target group and the fixed group overlap, the BS may check if there exist any backup channels allocated to a mobile group. When there are backup channels which are being allocated to mobile groups, and the target group and the mobile group do not overlap, the BS allocates the backup channels allocated to the mobile group (3). Although there are backup channels which are being allocated to the mobile group, but the mobile group and the target group are also overlap, the BS allocates the backup channels allocated to the fixed group or the mobile group (4). When there are also no backup channels which are being allocated to mobile groups, the BS allocates the backup channels allocated to the BS, to the target group (5). When at least two overlapping groups share the backup channels or when the BS and some groups share the backup channels, the BS may use a mechanism for proper resources sharing between the overlapping groups or the BS and some groups after channel switching.

8. Security mechanism in IEEE 802.22

9. PHY (Mode 1)

Change Table 198 as indicated.

Table AT1—System parameters

Parameters	Specifications	Remark
Frequency Range	54~862 MHz	
Channel bandwidth	6, 7, or 8 MHz	According to regulatory domain (see Annex A).
Data rate	4.54 to ~~22.69~~31.78 Mbit/s	See Table 202
Spectral Efficiency	0.76 to ~~3.78~~5.3 bit/(s·Hz)	See Table 202
Payload modulation	QPSK, 16-QAM, 64-QAM,256-QAM (optional), MD-TCM (optional)	BPSK used for preambles, pilots and CDMA codes.
Transmit EIRP	4W maximum for CPEs. 4W maximum for BS's in the USA regulatory domain.	Maximum EIRP for BS's may vary in other regulatory domains.
Multiple Access	OFDMA	
FFT Size (N_{FFT})	2048	
Cyclic Prefix Modes	1/4, 1/8, 1/16, 1/32	
Duplex	TDD	

9.2 Data Rates

Change Table 202 as indicated.

Table AU1—PHY Modes and their related modulations, coding rates and data rates for $T_{CP} = T_{FFT}/16$

PHY Mode	Modula-tion	Coding rate	Data rate (Mb/s)	Spectral Efficiency[3] (for 6 MHz bandwidth)
1	BPSK	Uncoded		
2	QPSK	1/2 Repetition: 4		
3	QPSK	1/2 Repetition: 3		
4	QPSK	1/2 Repetition: 2		
5	QPSK	1/2	4.54	0.76
6	QPSK	2/3	6.05	1.01
7	QPSK	3/4	6.81	1.13
8	QPSK	5/6	7.56	1.26
9	16-QAM	1/2	9.08	1.51
10	16-QAM	2/3	12.10	2.02
11	16-QAM	3/4	13.61	2.27
12	16-QAM	5/6	15.13	2.52
13	64-QAM	1/2	13.61	2.27
14	64-QAM	2/3	18.15	3.03
15	64-QAM	3/4	20.42	3.40
16	64-QAM	5/6	22.69	3.78
17	256-QAM	1/2	18.16	3.03
18	256-QAM	2/3	24.2	4.033
19	256-QAM	3/4	27.24	4.54
20	256-QAM	5/6	30.24	5.04
21	256-QAM	7/8	31.78	5.30
22	4D-48TCM	10/11 for 2*2D sym-bol	22.69	3.78
23	4D-192TCM	14/15 for 2*2D sym-bol	31.78	5.30

9.7 Channel coding

9.7.2.1.2 Puncturing

Change Table 208 as indicated

Table 208—Puncturing and bit-insertion for the different coding rates

Code rate	1/2	2/3	3/4	5/6	7/8
Convolutional coder output	A_1B_1	A_1B_1~~A_2~~B_2	A_1B_1~~A_2~~B_2A_3~~B_3~~	A_1B_1~~A_2~~B_2A_3~~B_3A_4~~B_4 A_5~~B_5~~	A_1B_1~~A_2~~B_2~~A_3~~B_3~~A_4~~B_4 A_5~~B_5A_6~~B_6A_7~~B_7~~
Puncturer output/ bit-inserter input	A_1B_1	$A_1B_1B_2$	$A_1B_1B_2A_3$	$A_1B_1B_2A_3B_4A_5$	$A_1B_1B_2B_3B_4A_5B_6A_7$
Decoder input	A_1B_1	$A_1B_10B_2$	$A_1B_10B_2A_30$	$A_1B_10B_2A_300B_4A_50$	$A_1B_10B_20B_30B_4A_500$ B_6A_70

9.7.2.1.3 OFDM slot concatenation

Change Table 209 as indicated.

Table 209—Concatenation index for different modulations and coding

Modulation and Rate	j
QPSK 1/2	12
QPSK 2/3	9
QPSK 3/4	8
QPSK 5/6	7
16-QAM 1/2	6
16-QAM 2/3	4
16-QAM 3/4	4

Table 209—Concatenation index for different modulations and coding

Modulation and Rate	j
16-QAM 5/6	3
64-QAM 1/2	4
64-QAM 2/3	3
64-QAM 3/4	2
64-QAM 5/6	2
256-QAM 1/2	3
256-QAM 2/3	2
256-QAM 3/4	2
256-QAM 5/6	1
256-QAM 7/8	1

Change Table 211 as indicated.

Table 211—Useful data payload in bytes for an FEC block

QPSK				16-QAM				64-QAM				256-QAM				
R= 1/2	**R= 2/3**	**R= 3/4**	**R= 5/6**	**R= 1/2**	**R= 2/3**	**R= 3/4**	**R= 5/6**	**R= 1/2**	**R= 2/3**	**R= 3/4**	**R= 5/6**	**R= 1/2**	**R= 2/3**	**R= 3/4**	**R= 5/6**	**R= 7/8**
3																
	4															
			5													
6				6												
	8				8											
9		9				9		9								
			10				10									
12	12			12					12			12				
15			15								15					
	16				16								16			

Table 211—Useful data payload in bytes for an FEC block

QPSK				16-QAM				64-QAM				256-QAM				
18		18		18		18		18						18		
	20		20				20								20	
21																21
24	24			24	24				24			24				
			25													
27		27				27		27		27						
	28															
30			30	30			30				30					
	32				32								32			
33																
			35											36		

9.8.1.1 Conventional QPSK and QAM

The output of the bit interleaver is entered serially to the constellation mapper. The input data to the mapper is first divided into groups of number of coded bits per carrier, i.e., N_{CBPC} bits and then converted into complex numbers representing QPSK, 16-QAM, 64-QAM, or 256-QAM constellation points. The mapping for QPSK, 16-QAM, 64-QAM, and 256-QAM is performed according to Gray-coding constellation mapping, as shown in Figure 150, Figure 151, and Figure AY1, respectively where b_0 represents the most significant modulation bit for all constellations.

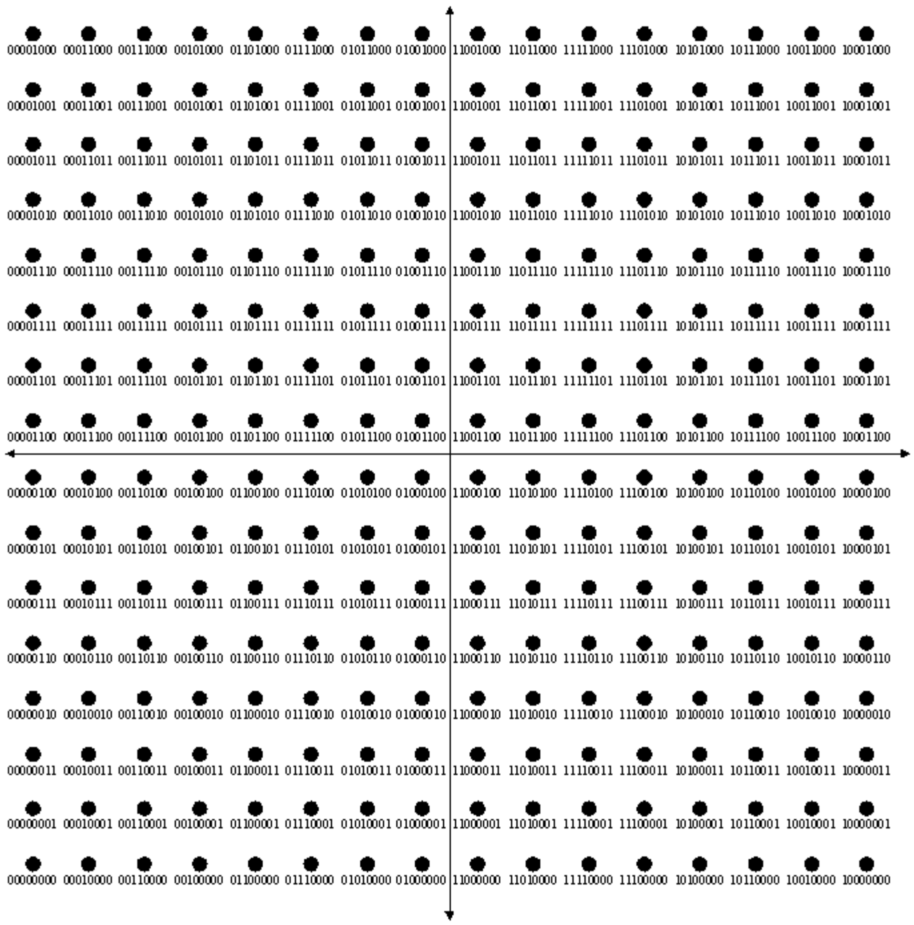

Figure AY1—Gray Mapping for 256-QAM

Change Table 226 and Table 227 as indicated.

Table 226—Number of coded bit per carrier and normalization factor for different modulation constellations

Modulation Type	N_{CBPC}	K_{MOD}
QPSK	2	$1/\sqrt{2}$
16-QAM	4	$1/\sqrt{10}$
64-QAM	6	$1/\sqrt{42}$
256-QAM	8	$1/\sqrt{170}$

Table 227—Number of coded bits per OFDM slot (N_{CBPS}) and corresponding number of data bits for different modulation constellation and coding rate combinations

Constellation type	Coding rate	N_{CBPS}	Corresponding number of data bits
QPSK	1/2	48	24
QPSK	2/3	48	32
QPSK	3/4	48	36
QPSK	5/6	48	40
16-QAM	1/2	96	48
16-QAM	2/3	96	64
16-QAM	3/4	96	72
16-QAM	5/6	96	80
64-QAM	½	144	72
64-QAM	2/3	144	96
64-QAM	3/4	144	108
64-QAM	5/6	144	120
256-QAM	1/2	192	96
256-QAM	2/3	192	128
256-QAM	3/4	192	144
256-QAM	5/6	192	160
256-QAM	7/8	192	168

9.8.1.2 QAM with multidimensional trellis coded modulation

The output of the multidimensional trellis encoder is entered to the constellation mapper. The input data to the mapper has a group of number of coded bits per two carriers, i.e., N_{CBPC} bits and then converted into complex numbers representing 48-QAM, or 192-QAM constellation points. The mapping for 48-QAM and 192-QAM are performed according to constellation mapping, as shown in Figure YYY and ZZZ, respectively.

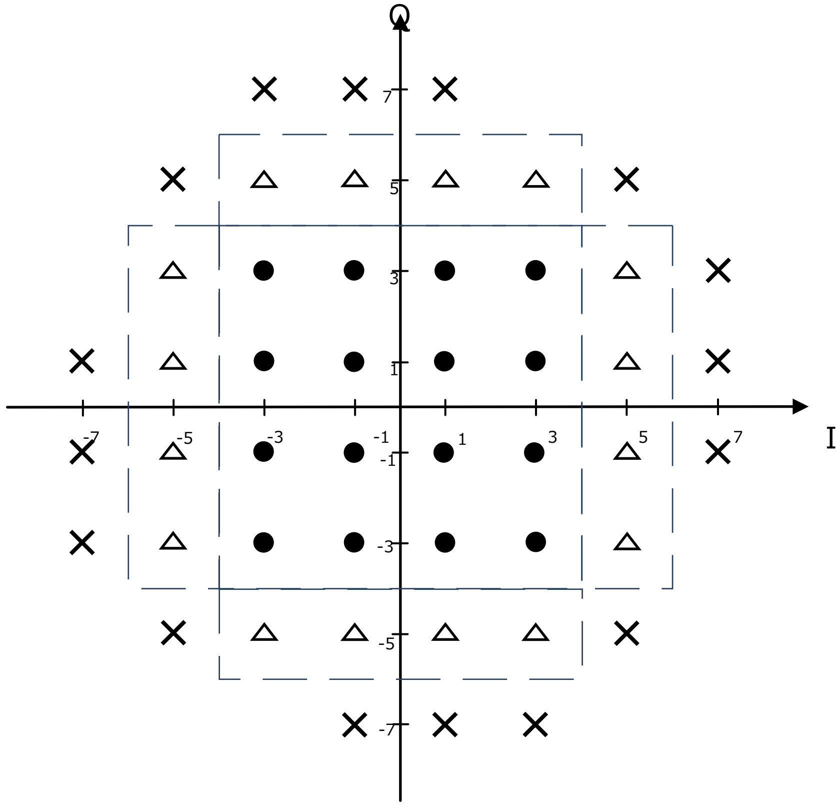

Figure AZ1—Constellation of one 2D symbol for MD-TCM 48 QAM

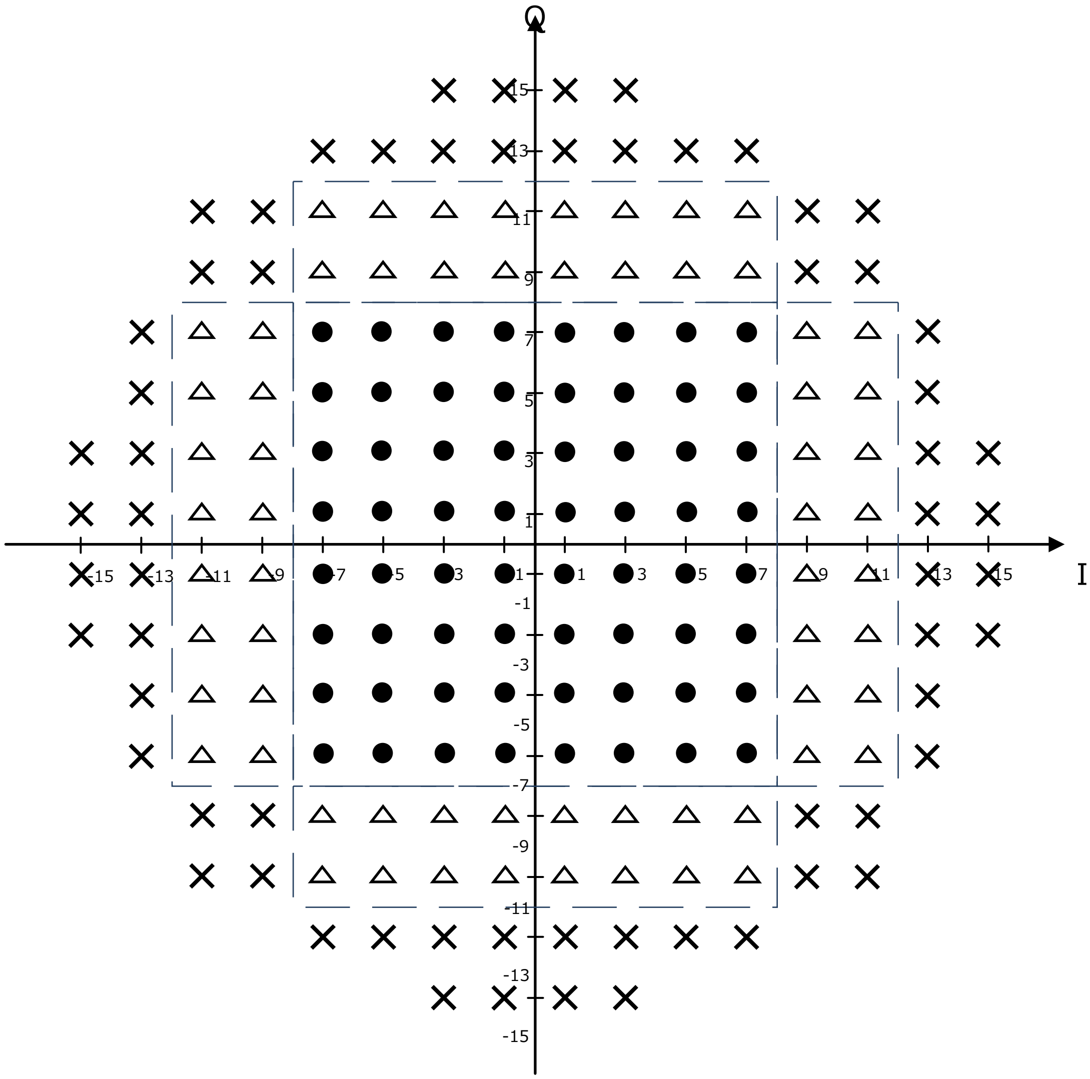

Figure BA1—Constellation of one 2D symbol for MD-TCM 192 QAM

9.9 Control mechanisms

9.9.4.2 Transmit Power Control mechanism

9.14 Receiver Requirements

9.14.1 Receiver minimum sensitivity

Required Signal-to-Noise Ratio = the Reference Normalized SNR as shown in Figure 228 for a BER performance of $2x10^{-4}$ where the values include 1.1 dB, 1.3 dB, 1.5 dB, and 1.7 dB decoder implementation margins for QPSK, 16-QAM, 64-QAM, and 256-QAM modulations respectively;

Table 228—Normalized CNR per modulation for BER= $2*10^{-4}$

Modulation - FEC rate	Normalized CNR (dB)	
	AWGN (default)	Multipath Channel (informative)
CDMA code	1.2	5
QPSK, rate: 1/2	4.3	8.1
QPSK, rate: 2/3	6.1	11.6
QPSK, rate: 3/4	7.1	14.0
QPSK, rate: 5/6	8.1	17.8
16-QAM, rate: 1/2	10.2	14.8
16-QAM, rate: 2/3	12.4	20.3
16-QAM, rate: 3/4	13.5	24.6
16-QAM, rate: 5/6	14.8	28.6
64-QAM, rate: 1/2	15.6	20.5
64-QAM, rate: 2/3	18.3	26.2
64-QAM, rate: 3/4	19.7	31.8
64-QAM, rate: 5/6	20.9	40.4
256-QAM, rate: 1/2	19.4	TBD
256-QAM, rate: 2/3	22.6	TBD
256-QAM, rate: 3/4	24.2	TBD
256-QAM, rate: 5/6	26.2	TBD
256-QAM, rate: 7/8	27.5	TBD

9a. PHY (Mode 2)

This clause specifies the basic technologies for the standardization of the physical (PHY) layer for WRAN systems. The specification is for a system that uses vacant channels to provide wireless communication.

The system reference frequency is the center frequency of the channel in which the transmitter and the receiver equipment operates. Annex A lists the frequencies corresponding to the channels used for WRAN operation in various regulatory domains.

The PHY specification is based on an orthogonal frequency division multiple access (OFDMA) scheme where information to (downstream) or from (upstream) multiple CPEs are modulated on orthogonal subcarriers using Inverse Fourier Transforms. The main system parameters are provided in Table AV1.

The following subclauses provide details on the various aspects of the PHY specifications.

Table AV1—System parameters

Parameters	Specifications	Remark
Frequency Range	54~862 MHz	
Channel bandwidth	6, 7, or 8 MHz	According to regulatory domain (see Annex A).
Data rate	3.61 to 18.07 Mbit/s for SISO case 14.44 to 72.28 Mbit/s for 4 × 4 MIMO case	See Table AZ1
Spectral Efficiency	0.60 to 3.01 bit/(s/Hz)	See Table AZ1
Payload modulation	QPSK, 16-QAM, 64-QAM	BPSK used for preambles, pilots and CDMA codes.
Transmit EIRP	4W maximum for CPEs. 4W maximum for BS's in the USA regulatory domain.	Maximum EIRP for BS's may vary in other regulatory domains.
Multiple Access	OFDMA	
FFT Size (N_{FFT})	1024	
Cyclic Prefix Modes	1/4, 1/8, 1/16, 1/32	
Duplex	TDD	

9a.1 Symbol description

9a.1.1 OFDM symbol mathematical representation

The RF signal transmitted during any OFDM symbol duration can be represented mathematically as follows:

$$s(t) = \mathrm{Re}\left\{ e^{j2\pi f_c t} \sum_{\substack{k=-N_T/2 \\ k\neq 0}}^{N_T/2} c_k e^{j2\pi k\Delta f(t-T_{CP})} \right\}$$

t is the time elapsed since the beginning of the current symbol, with $0<t<T$

T is the symbol duration, including cyclic prefix duration

Re(.) real part of the signal

f is the carrier frequency

c is a complex number; the data to be transmitted on the subcarrier whose frequency offset index is *k*, during the current symbol. It specifies a point in a QAM constellation.

Δf is the subcarrier frequency spacing

T is the time duration of cyclic prefix

N is the number of used subcarriers (not including DC subcarrier)

9a.1.1.1 Time domain description

The time-domain signal is generated by taking the inverse Fourier transform of the length N_{FFT} vector. The vector is formed by taking the constellation mapper output and inserting pilot and guard tones. At the receiver, the time domain signal is transformed to the frequency domain representation by using a Fourier transform.

Let T_{FFT} represent the time duration of the IFFT output signal. The OFDM symbol is formed by inserting a cyclic prefix of time duration T_{CP} (shown in Figure BB1), resulting in a symbol duration of $T_{SYM} = T_{FFT} + T_{CP}$.

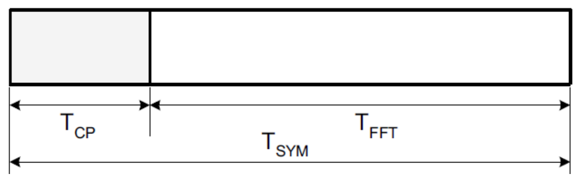

Figure BB1—OFDM symbol format

The specific values for T_{FFT}, T_{CP} and T_{SYM} are given in 9a.1.2. The BS determines these parameters and conveys the T_{CP} to T_{FFT} ratio to the CPEs using the FCH.

The time at which the FFT window starts within the symbol period for reception at the CPE is determined by the local synchronization strategy to minimize inter-symbol interference due to pre- and post-echoes and any synchronization error, and is implementation dependent.

9a.1.1.2 Frequency domain description

In the frequency domain, an OFDM symbol is defined in terms of its subcarriers. The subcarriers are classified as: 1) data subcarriers, 2) pilot subcarriers, 3) guard and null (including DC) subcarriers. The classification is based on the functionality of the subcarriers. The DS and US may have different allocations of subcarriers. The total number of subcarriers is determined by the FFT/IFFT size. The pilot subcarriers are distributed across the bandwidth. The exact location of the pilot and data subcarriers and the symbol's subchannel allocation is determined by the particular configuration used. All the remaining guard/null subcarriers carry no energy and are located at the center frequency of the channel (DC subcarrier) and at both edges of the channel (guard subcarriers).

9a.1.2 Symbol parameters

9a.1.2.1 Subcarrier spacing

The BS and CPEs shall use the 1024 FFT mode with the subcarriers spacing specified in Table AW1. The subcarrier spacing, ΔF, is dependent on the bandwidth of the channel (6 MHz, 7 MHz, or 8 MHz). Table AW1 shows the subcarrier spacing and the corresponding FFT/IFFT period (T_{FFT}) values for the different channel bandwidth options.

Table AW1—Subcarrier spacing and FFT/IFFT period values for different bandwidth options

	6 MHz based channels	7 MHz based channels	8 MHz based channels
Basic sampling frequency, F_s (MHz)	5.6	6.53	7.46
Inter-carrier spacing Δf (Hz)= F_s /1024	5468.75	6380.208…	7291.6…
FFT/IFFT period, T_{FFT}(μs)=1/ Δf	182.857…	156.734…	137.142…
Time Unit (ns) TU=T_{FFT}/1024	178.571…	153.061…	133.928…

9a.1.2.2 Symbol duration for different cyclic prefix modes

The cyclic prefix duration T_{CP} could be one of the following derived values: $T_{FFT}/32$, $T_{FFT}/16$, $T_{FFT}/8$, and $T_{FFT}/4$. The OFDM symbol duration for different values of cyclic prefix is given in Table AX1.

Table AX1—Symbol duration for different cyclic prefixes and bandwidth options

		CP=T_{FFT}/32	CP=T_{FFT}/16	CP=T_{FFT}/8	CP=T_{FFT}/4
T_{SYM} =T_{FFT}+T_{CP} (μs)	6 MHz	188.571…	194.285…	205.714…	228.571…
	7 MHz	161.632…	166.530…	176.326…	195.918…
	8 MHz	141.428…	145.714…	154.285…	171.428..

9a.1.2.3 Transmission parameters

Table AY1 shows the different parameters and their values for the three bandwidths.

Table AY1—OFDM parameters for the three channel bandwidths

TV channel bandwidth (MHz)	6	7	8
Total number of subcarriers, N_{FFT}	1024		
Number of guard subcarriers, N_G (L, DC, R)	192 (96,1,95) for DS 184 (92,1,91) for US		
Number of used subcarriers $N_T = N_D + N_P$	832 for DS 840 for US		
Number of data subcarriers, N_D	832 or 416 for DS 840 or 420 for US		
Number of pilot subcarriers, N_P	0 or 416 for DS 0 or 420 for US		

9a.1.3 OFDMA basic terms definition

9a.1.3.1 Tile, slot and data region

In DS, a tile consists of 4 successive active subcarriers and 4 OFDM symbols as shown in Figure BC1. In US, a tile consists of 4 successive active subcarriers and 7 OFDM symbols as shown in Figure BD1.

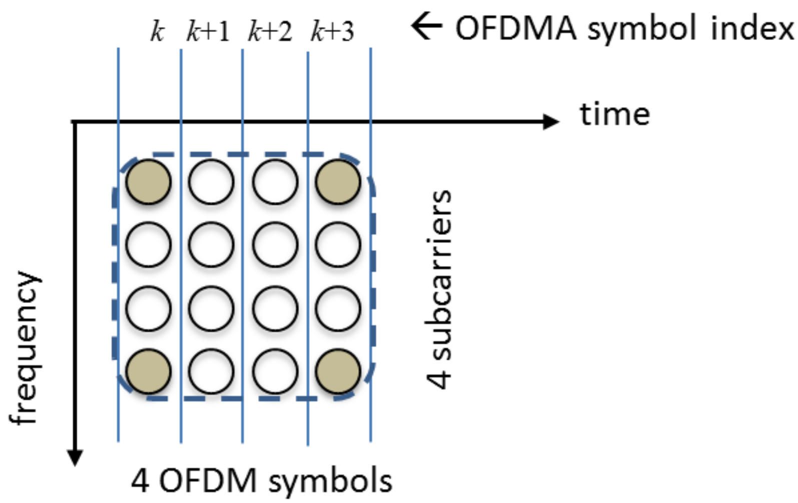

Figure BC1—Tile configuration for DS

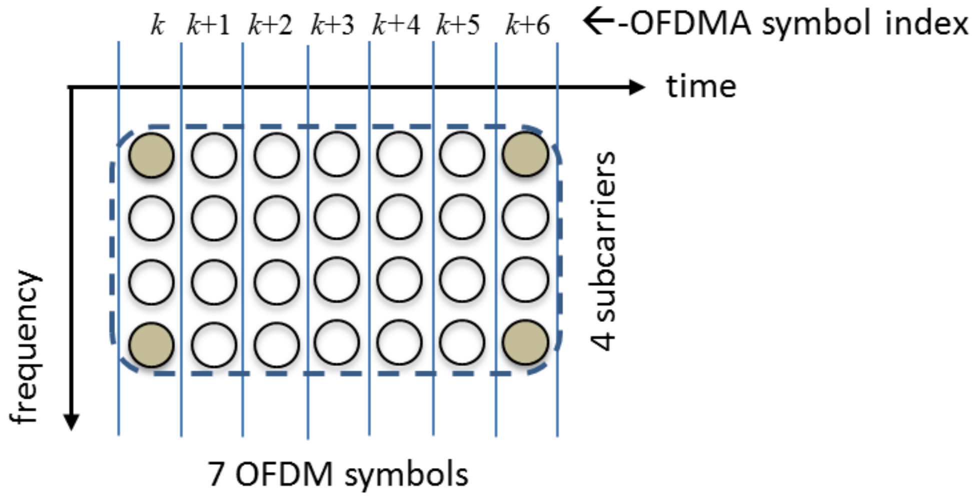

Figure BD1—Tile configuration for US

A slot is the minimum possible data allocation unit. A slot requires both a time and subchannel dimension. In DS, a slot consists of 16 subcarriers and 4 OFDM symbols (or 4 DS tiles) as shown in Figure BE1. In US, a tile consists of 8 subcarriers and 7 OFDM symbols (or 2 US tiles) as shown in Figure BF1

.

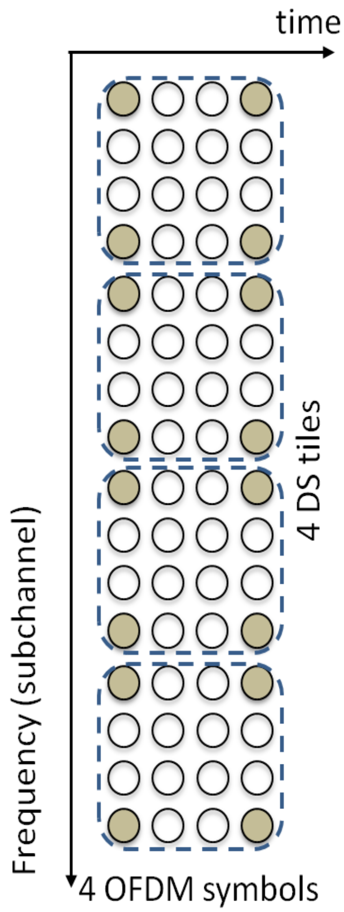

Figure BE1—Slot configuration for DS

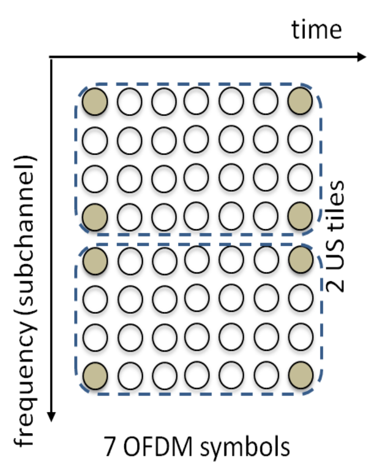

Figure BF1—Slot configuration for US

A data region is a two-dimensional allocation of a group of contiguous subchannels, in a group of contiguous OFDMA symbols. All the allocations refer to logical subchannels. A two-dimensional allocation may be visualized as a rectangle, such as the 8 x 5 rectangles shown in Figure BG1.

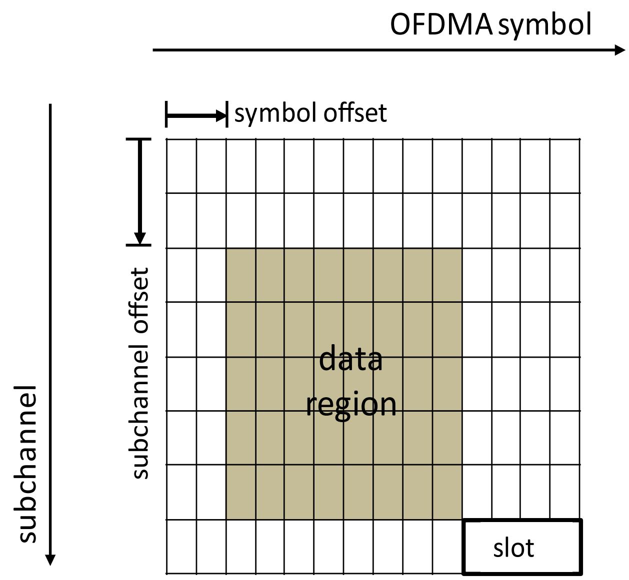

Figure BG1—Example of a data region that defines an OFDMA allocation (DS)

9a.1.3.2 Data mapping

MAC data shall be processed as described in 9a.7 and shall be mapped to a data region (see 9a.1.3.1) for DS and US using the algorithms defined below.

DS:

a) Segment the data into blocks sized to fit into one slot.

b) Each slot shall span one subchannels in the subchannel axis and 4 OFDM symbols in the time axis, as per the slot definition in 9a.1.3.1. Map the slots so that the lowest numbered slot occupies the lowest numbered subchannel in the lowest numbered symbol.

c) Continue the mapping so that the subchannel index is increased. When the edge of the data region is reached, continue the mapping from the lowest numbered subchannel in the next available symbol.

Figure BH1 illustrates the order in which OFDMA slots are mapped to subchannels and OFDMA symbols in

DS.

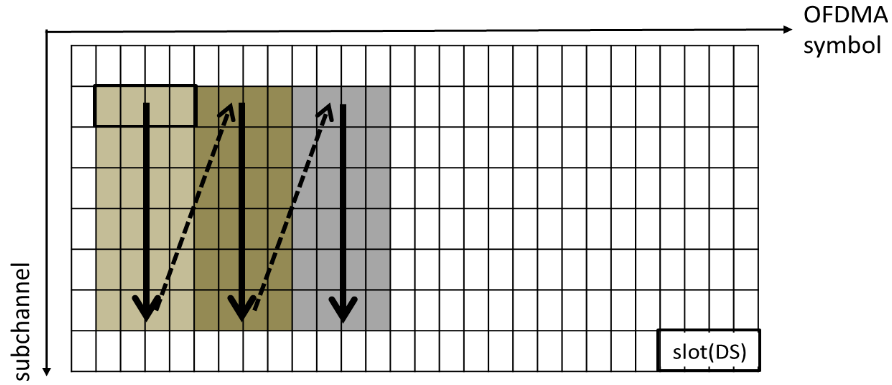

Figure BH1—Procedure of slot allocation to the burst (data region) in DS

US:

The US mapping consists of two steps. In the first step, the slots allocated to each burst (a data region) are selected. In the second step, the allocated slots are mapped.

Step 1—Allocate slots to bursts.

d) Segment the data into blocks sized to fit into one slot.

e) Each slot shall span one subchannel in the subchannel axis and 7 OFDM symbols in the time axis, as per the slot definition in Figure BF1. Allocate the slots so that the lowest numbered slot occupies the lowest numbered symbol in the lowest numbered subchannel.

f) Continue allocating such that the OFDMA symbol index is increased. When the edge of the allocated data region is reached, continue allocating from the lowest numbered symbol in the next available subchannel.

g) An US allocation is created by selecting an integer number of contiguous slots, according to the ordering of items d) through f). This results in the general burst structure shown by the gray area in Figure BI1.

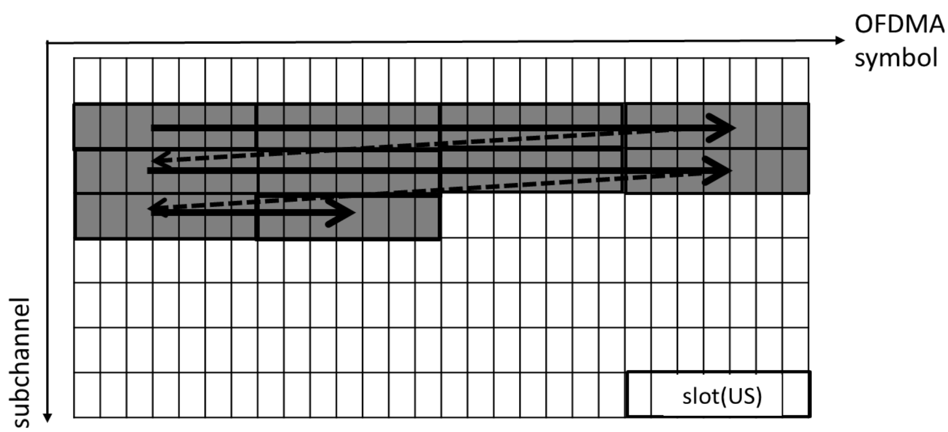

Figure BI1—Slot allocation to the allocated data region (burst) in US

Step 2—Map slots within the UL allocation.

h) Map the slots so that the lowest numbered slot occupies the lowest numbered subchannel in the lowest numbered OFDMA symbol.

i) Continue the mapping so that the subchannel index is increased. When the last subchannel is reached, continue the mapping from the lowest numbered subchannel in the next OFDMA symbol that belongs to the UL allocation. The resulting order is shown by the arrows in Figure BJ1.

Figure BJ1 illustrates the order in which OFDMA slots are mapped to subchannels and OFDMA symbols in US.

The subchannels referred to in this subclause are logical subchannels,

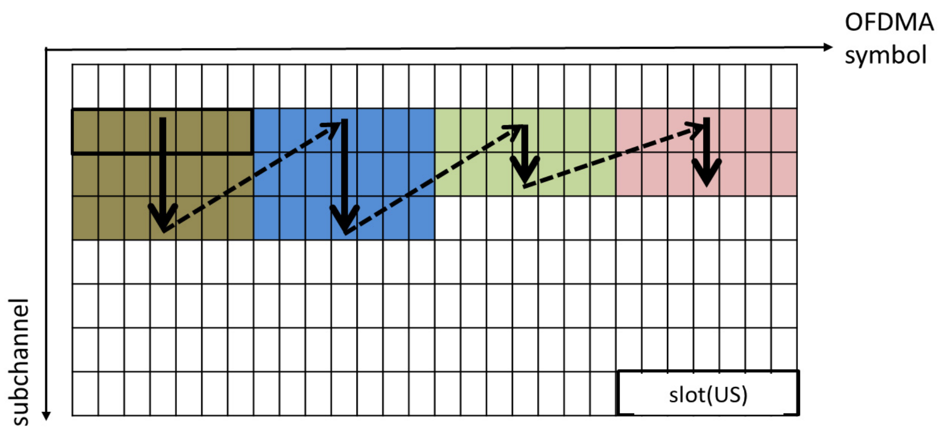

Figure BJ1—Example of mapping slots to subchannels and symbols in the US

9a.2 Data rates

Table AZ1 defines the different PHY modulation and encoding modes with their associated parameters along with an example of the resulting gross data rates in the case of the 6 MHz channel bandwidth.

Table AZ1—PHY Modes and their related modulations, coding rates and data rates for $T_{CP} = T_{FFT}/16$

PHY Mode	Modulation	Coding rate	Data rate (Mb/s)	Spectral Efficiency[3] (for 6 MHz bandwidth)
1[1]	BPSK	Uncoded	4	4
2[2]	QPSK	1/2Repetition: 4	4	4
3	QPSK	1/2	3.61	0.60
4	QPSK	2/3	4.82	0.80
5	QPSK	3/4	5.42	0.90
6	QPSK	5/6	6.02	1.00
7	16-QAM	1/2	7.23	1.21
8	16-QAM	2/3	9.64	1.61
9	16-QAM	3/4	10.84	1.81
10	16-QAM	5/6	12.05	2.01
11	64-QAM	1/2	10.84	1.81
12	64-QAM	2/3	14.46	2.41
13	64-QAM	3/4	16.26	2.71
14	64-QAM	5/6	18.07	3.01

NOTE 1: Mode 1 is only used for CDMA opportunistic bursts.
NOTE 2: Mode 2 is only used for FCH and DRZ-FCH transmission.
NOTE 3: Spectral efficiency informative values are calculated assuming continuous stream for the given modulation and FEC modes (i.e., assuming no TTG, RTG or frame headers).
NOTE 4: These modes are for control signal transmissions and there is no need to specify data rate or spectral efficiency.

9a.3 Functional block diagram applicable to the PHY layer

The functional block diagram of the transmitter and receiver for the PHY layer is shown in Figure BK1. This subclause describes the general processing of the WRAN baseband signal. The binary data intended for transmission is supplied to the PHY layer from the MAC layer. This input is sent to a channel coding processor which includes a data scrambler, encoder, puncturer (a bit interleaver specified in 9a.6.4. The interleaved data is mapped to data constellations as described in 9a.8 according to the modulation schemes specified as shown in Table AZ1. The subcarrier allocator assigns the data constellations to the corresponding subchannels according to the subcarrier allocation methods described in 9a.6.2 and 9a.6.3.

A frame has its first OFDM symbol occupied by the frame preamble in 9a.4.1.1. The pilot subcarriers are transmitted at fixed positions in the frequency domain within each OFDM data symbol as specified in 9a.6.1. Preambles and pilots can support the synchronization, channel estimation and tracking process. In the frequency-domain, an OFDM symbol contains the data, pilot, and null subcarriers, as defined in Table AY1. The resultant stream of constellations is subsequently input to an inverse Discrete Fourier Transform after a serial-to-parallel conversion. The inverse Fast Fourier Transform (IFFT) is the expected means of performing the inverse Discrete Fourier Transform. In order to prevent inter-symbol interference (ISI) eventually caused by the channel delay spread, the OFDM symbol is extended by a cyclic prefix that contains the same waveform as the corresponding ending part of the symbol. Finally, the OFDM signal is transferred to the RF transmission modules via a digital-to-analog converter.

The OFDM receiver roughly implements the same operations as performed by the transmitter but in reverse order. In addition to the data processing, synchronization and channel estimation must be performed at the receiver.

The CBP packet can also be generated through the same process as that used for the data transmission. The CBP packet subcarrier allocation, preamble and pilot patterns are described in 9a.5.

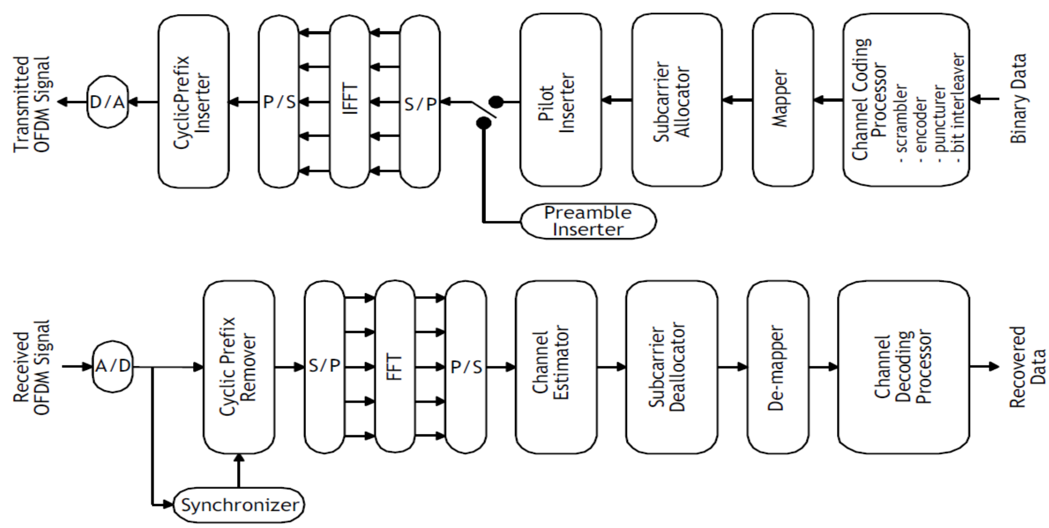

Figure BK1—Transmitter and receiver block diagram for the OFDMA PHY

9a.4 Frame structure

The basic frame structure is shown in Figure 12. See Figure 7.4a for a full description of the frame structure.

Each frame contains a preamble, header, and data bursts.

For both normal and self-coexistence operational modes, the first symbol shall be the frame preamble. The second to fifth symbols shall contain the FCH, and DS-MAP, US-MAP, when needed, DCD and UCD, and data bursts if there is some room left. The FCH specifies the length of the first MAP that will immediately follow the FCH.

In each frame, a TTG shall be inserted between the downstream and upstream bursts to allow the CPE to switch between the receive mode and transmit mode and to absorb the signal propagation time. A RTG shall be inserted at the end of each frame to allow the BS to switch between its receiving mode and transmit mode (see Figure B1).

The values indicated in Table BA1 for the TTG and RTG shall be used for the specified cyclic prefixes and channel bandwidth options.

Table BA1—WRAN frame parameters

Cyclic Prefix	Number of symbols per frame[1]			Transmit-receive turnaround gap[2] (TTG)			Receive-transmit turnaround gap[3] (RTG)		
BW	6 MHz	7MH	8MHz	6 MHz	7MH	8MHz	6 MHz	7MH	8MHz
1/4	41	48	55	1185 TU	1382 TU	1579 TU	1056 TU	1232 TU	1408 TU
1/8	46	54	61	1185 TU	1382 TU	1579 TU	672 TU	592 TU	1665 TU
1/16	48	57	65	1185 TU	1382 TU	1579 TU	1504 TU	848 TU	1280 TU
1/32	50	59	67	1185 TU	1382 TU	1579 TU	960 TU	592 TU	1280 TU

NOTE 1—Indicates the DS/US payload symbols and symbols for FCH, DS/US MAP and DCD/UCD. Here, one frame preamble symbol is assumed. Different values may apply when the frame carries more header symbols.
NOTE 2—Example of TTG set to absorb the propagation delay
NOTE 3—Portion of symbol left over to arrive at the 10 ms frame period.

9a.4.1 Preamble

9a.4.1.1 Frame preamble

The first symbol of the DS transmission is the preamble. Three different preamble carriersets are defined, differing in the allocation of subcarriers. Those subcarriers are modulated using a boosted BPSK modulation with a specific pseudo-noise (PN) code.

The preamble carrier-sets are defined using Equation (1).

$$PreambleCarrierSet_n = n + 3k \quad (1)$$

where

$PreambleCarrierSet_n$ specifies all subcarriers allocated to the specific preamble

n is the designating number of the preamble carrier-set indexed 0, 1, and 2

k is a running index. 0...283

Each segment uses a preamble composed of a single carrier-set in the following manner:

— Segment 0 uses preamble carrier-set 0 (n =0).

— Segment 1 uses preamble carrier-set 1 (n =1).

— Segment 2 uses preamble carrier-set 2 (n =2) .

In the case of segment 0, the DC carrier will not be modulated at all, and the appropriate PN will be discarded. Therefore, the DC carrier shall always be zeroed.

Each segment eventually modulates each third subcarrier. As an example, Figure BL1 depicts the preamble of segment 0. In this figure, subcarrier 0 corresponds to the first subcarrier used in the preamble symbol.

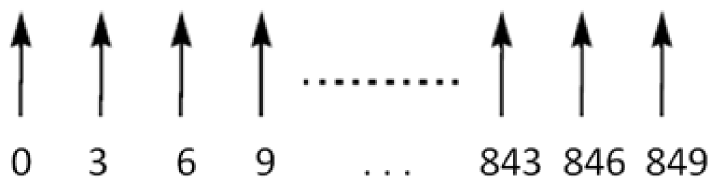

Figure BL1—Example of basic structure of preamble (for the case of *n* =0)

The PN series modulating the preamble carrier-set is defined in Table BB1. The series modulated depends on the segment used and IDcell parameter. The defined series shall be mapped onto the preamble subcarriers in ascending order. Figure BB1 includes the PN sequence in an hexadecimal format. The value of the PN is obtained by converting the series to a binary series (W_k) and mapping the PN starting from the MSB of each symbol to the LSB (0 mapped to +1 and 1 mapped to –1). For example, for Index = 0, IDcell=0, and Segment = 0 (the first row of Table BB1), W_k = 101001101111..., and the mapping shall follow: –1 +1 –1 +1 +1 –1 –1 +1 –1 –1 –1 –1....

For the preamble symbol, there will be 86 guard band subcarriers on each side of the spectrum.

The symbols in the DS preamble shall be modulated according to Equation (2).

$$\mathrm{Re}\{PreambleModulated\} = 4 \cdot \sqrt{2} \cdot \left(\frac{1}{2} - W_k\right) \ , \ \mathrm{Im}\{PreambleModulated\} = 0 \quad (2)$$

Table BB1—Preamble modulation series per segment and Cell ID

Index	Cell ID	Segment	Series to modulate (W_k)
0	0	0	0xA6F294537B285E1844677D133E4D53CCB1F182DE00489E53E6B6E77065C7EE7D0ADBEAF
1	1	0	0x668321CBBE7F462E6C2A07E8BBDA2C7F7946D5F69E35AC8ACF7D64AB4A33C467001F3B2
2	2	0	0x1C75D30B2DF72CEC9117A0BD8EAF8E0502461FC07456AC906ADE03E9B5AB5E1D3F98C6E
3	3	0	0x5F9A2E5CA7CC69A5227104FB1CC2262809F3B10D0542B9BDFDA4A73A7046096DF0E8D3D

Table BB1—Preamble modulation series per segment and Cell ID

Index	Cell ID	Segment	Series to modulate (W_k)
4	4	0	0x82F8A0AB918138D84BB86224F6C342D81BC8BFE791CA9EB54096159D672E91C6E13032F
5	5	0	0xEE27E59B84CCF15BB1565EF90D478CD2C49EE8A70DE368EED7C9420B0C6FFAF9AF035FC
6	6	0	0xC1DF5AE28D1CA6A8917BCDAF4E73BD93F931C44F93C3F12F0132FB643EFD5885C8B2BC
7	7	0	0xFCA36CCCF7F3E0602696DF745A68DB948C57DFA9575BEA1F05725C42155898F0A63A248
8	8	0	0x024B0718DE6474473A08C8B151AED124798F15D1FFCCD0DE574C5D2C52A42EEF858DBA5
9	9	0	0xD4EBFCC3F5A0332BEA5B309ACB04685B8D1BB4CB49F9251461B4ABA255897148F0FF238
10	10	0	0xEEA213F429EB926D1BDEC03ABB67D1DE47B4738F3E929854F83D18B216095E6F546DADE
11	11	0	0xC03036FA9F253045DF6C0889A8B83BAEFCF90EB993C2D79BD911CA84075061AA43DA471
12	12	0	0x1E68EC22E5E2947FB0A29E4CC70597254B36C60331EACF779FE752D3F55DC41ABFC7DC9
13	13	0	0x63A57E75A0434F035AAC4504B265081D497F10C77928B71797C5D6C6824DC0F23BE34EE
14	14	0	0xC57C4612816DE981C58FD6F8DE9DD41F2422ADBC522B0CE31F9A6D5F2A126DC08F69FB1
15	15	0	0x978256AF184E7ED17789B33D324C711B36BFBCCE5446EB03687E9A0A839C7CE156104D2
16	16	0	0x011EC823157DD73150640CEB7DDB0A1F8F91E09599A851D5C7CAF687CFB752D297D82FC
17	17	0	0xC6DE82BEB7F57B9120E8A376D85C8F70FDC65BC660402DAC4AE6002EA2740C4F9E5973C
18	18	0	0x4C74929D6F9FAB9E5BB761026038E076F6824295E0AF397806ECEBC6DC713F03ACDC27C
19	19	0	0x13E1E85C2234D0F3418001A35F135E10C6C918C36BC659FDA9D655D288A0BDAA8BF489D
20	20	0	0xFD4AF2D8F4F08F1A7DF59291C9AEE788F641B8231CFB813376E0BEB68DFCFCBBE552445
21	21	0	0xEBBC77A493AA0C62C62F25EE5E8D0701F50386F49026FA31487C9FD5C5206CE4EB00576

Table BB1—Preamble modulation series per segment and Cell ID

Index	Cell ID	Segment	Series to modulate (W_k)
22	22	0	0x134F936F9E875842587ADCA92187F2FC6D62FFC3A833D8CDE465F9972ABAA83763AAEB7
23	23	0	0x3CD1DA70670BC73363D1B4A66D280FF6AA7636D07ECF32BA26101E5EBA1594FB8A0420A
24	24	0	0x918296B2937C2B6F73CF98F85A81B723D1C69DBDF3E019749C582DA22E789562729D475
25	25	0	0xC323981B8B2240865F48D61AE1B3B61D88522B7358952F949D4308CA15D1EE8FDFA683F
26	26	0	0x7514A6FA5FBB250C5C8CE96F791D676036C344A44B24284477B44CB3E758F8BCD58F05B
27	27	0	0x84C7FEC6E977FA1EC0C7CC9E0D067C73D8F846F82ABB3456D2104E1448D5A58D5975152
28	28	0	0x4841AFC277B86A0E067AF319422F501C87ACBFBDD66BFEA3644F879AE98BA8C5D605123
29	29	0	0xF35EA87318E459138A2CE69169AD5FD9F30B62DA04ED21320A9F59893F0D176752152FD
30	30	0	0xA0C5F35C5971CD3DC55D7D2B9FD27AA17A198583F580EB0800744EE5B6B3648DEA95840
31	31	0	0xA6D3D33AD9B56862DBF076E3ACE6A3150510CCC8BE77DE4E6E10EB5FE163765647D07DF
32	0	1	0x52849D8F020EA6583032917F36E8B62DFD18AD4D77A7D2D8EC2D4F20CC0C75B7D4DF708
33	1	1	0xCC53A152209DEC7E61A06195E3FA633076F7AE1BAFFE83CE565087C0507BA596E0BD990
34	2	1	0x17D98A7E32CCA9B142FE32DB37B2BF726E25AA7A557FFB5C400B47A38B16CF18E1EDE63
35	3	1	0xA5BA8C7E2C795C9F84EBBD425992766BDE5549A7A9F7EF7E44AFD941C6084568638FE84
36	4	1	0x33E57E78A5696255CA61AE36027036DA619E493A0A8F95D9915C6E61F3006CB9706BEBA
37	5	1	0x09961E7309A9B7F3929C370C51910EBAB1B4F409FA976AE8679F354C84C4051F371F902
38	6	1	0x508A9EBAEF3C7E09CFCFC0B6F444A09B45A130EFC8C5B22BCE87213854E7C9D329C9ADC
39	7	1	0xAACEEF9BCDC82E4AD525185B07CBABCB74861D16F7C25CFBA917B05463AD65391AF840D

Table BB1—Preamble modulation series per segment and Cell ID

Index	Cell ID	Segment	Series to modulate (W_k)
40	8	1	0x23060ACC5A125DAB207EEEE47B4EEE1E8466BD17DDA2EB3CD90D2AB7A758C213E6D7FE5
41	9	1	0xCA55521667BDA8B6F1B205201A51B3A0C05DE9EA06BC73268730A81A992777021F46055
42	10	1	0x05ADFCA2F8207DC6FF8D1A85A1DD4694D4C48A838C4F833C532710021AC448A7B62B8DD
43	11	1	0x218C951223D7B712DC98F8B5217388A830003C5F2A00F232DD3475D2FC78C25B8D88FF9
44	12	1	0x79B94D24D721121EF678B7156F8D2666DE712BBF3837C85A951878190З146A7B4D42A28
45	13	1	0x58AABEF6A6BDE4011CAC583C5104B2C6FC5A2980F856373E5931A3C690245327581FA13
46	14	1	0x427D1AD18E338E16FCE6E23B4AD6D82A2144D53048F2665AA94577AFABD26889FCB1F9F
47	15	1	0x337FE0E4C15A22471AE0F6B6F91161A7DE2E1403D73587D5C8355105D2F70642B2CE425
48	16	1	0xA3FCAA311B536AC9DB39FED9F4E996506B3181C58D6B7E04157A3FD463F60468765BCFD
49	17	1	0xF484FD1F57F53A4A749B86148E0B1D0653667CE1393198875DDB0AE9179BBBDAAD53A11
50	18	1	0xA3E9ECF1E6048562BC89DB6168E708855F0D4AD29F859EF36C9160DF407D85426233632
51	19	1	0x890519376D1FFAA2894EABCD6663B0A3C2411982C17B01270E0FB0B289D4BC8C3B83D
52	20	1	0x09847B6187BB5F6F6728B4ED610088FAD9DADFC00748E9DCD8A0CE320D6C991654ABE05
53	21	1	0x3285AE0A3D196313659C37BE1C94D61D20F11FD49D9FDF9D1026FF5763F02CB78AE135C
54	22	1	0x0069D3F34D0D455AFB45FEFDF716333B785C6BDA90DA23F1CC68BC6A1DBC916C595DA3E
55	23	1	0xAA977A8BCA39381E7C35A1ACC7C4F60421C0862BFD6106C7C025B0676EA0EF68972DD8F
56	24	1	0xF310745C497094ABE56E0490C0800319DBE290553E696B6859635AF03B121F79D925D19
57	25	1	0x964DFD350B9C7DFDC7F6F7C43283A76F0D613E48A5520D1DAF761C6F47E389B43A023F5

Table BB1—Preamble modulation series per segment and Cell ID

Index	Cell ID	Segment	Series to modulate (W_k)
58	26	1	0x6D767B88D28A455CC3B56C942BAFD8E465A50FD2C22FE6162E03A9AAC3C1CC899800610
59	27	1	0xC5491C6CA3D998906EC1482F815B74B7C2E3816B682ACC6009AB7EFF34BF0E9CE59C754
60	28	1	0x6D8EE32D30E19D93A0E5AD8226BAE9CF6FCBA17CF6E67FDC5A15A81ECB8908BEDD77C80
61	29	1	0x98F8BFDF774C7A249418E6FF4723D6E6AB2F091CDE4DE1CE11D3BD463B509FB716940FD
62	30	1	0x65300BAD8FFA21BC7DC2C1F79FA97A9F469CCC9E270A61759F34D6276F57CBEB009CD21
63	31	1	0x6F36BB6D5A7DC4FB720439E91FF0DE86DD6C4B93CFC4271F2BCC6169616E3AEAA19E360
64	0	2	0xD27B00C70A8AA2C036ADD4E99D047A376B363FEDC287B8FD1A7794818C5873ECD0D3D56
65	1	2	0xE7FDDCEED8D31B2C0752D976DE92BEA241A713CF818C274AA1C2E3862C7EB7023AF35D4
66	2	2	0x87BF4954022D30549DF7348477EACB97AC3565B838460CC62F242883313B15C31370335
67	3	2	0x82DD830BEDE4F13C76E4CF9AEF5E42609F0BDDCB000A742B6372DD5225B0C3114494746
68	4	2	0x4E06E4CF46E1F5691938D7F40179D8F79A85216775384BD97966DB4BBF49FB6FAB8F945
69	5	2	0x64164534569A5E670FDB390D09C04802DD6A16B022CADC77EDD7464AFED43C773A8DC76
70	6	2	0xFB8769A81AA9DB607F14A6A95948401F83057CDC9C9C3996BA5821403A49F00A4E35191
71	7	2	0x77710D6F40B4F79CC63F678551C3EC18FA9DF2C82E6C8F415DADFD63264B7513180070E
72	8	2	0x503F196BBF93C238BFD5E735E5AE52E0DAE64F5E2F4C3B92E553F51303C4A64C4403BF3
73	9	2	0x5FD4A6894566678C95B9D5A59DDE5366799045FEB03A2BAA74094140E9068C61C2E972C
74	10	2	0x95B584DC40C8B5DEAD63D48FCE65B1E61BAB4C597D921DB12677141E2FFE7C0AA3DA0D5
75	11	2	0x985763AB6CC8934DB8A0BE738A7AF1D1FA3958C1F9E2D6A51A163E47A0A6E5FEB759FDD

Table BB1—Preamble modulation series per segment and Cell ID

Index	Cell ID	Segment	Series to modulate (W_k)
76	12	2	0xFD8D45F00D943AD986BD353D61C6746DBF8A309B6AE1C173B880D957B76DC031A957E8D
77	13	2	0xAE4323534F6EFB1A20169328417885EF304FA220389FA9C2607E5A406F4CE4A7498A39F
78	14	2	0xE5205579893BE184CB9948C28E2F9AAF699D47B6E5E0B219CBEAFE4BEC8D561BD809E34
79	15	2	0xAB11D6941478D36D5695CE813070DC1E32122A39083E53FE373660AEB125D83383FBDCA
80	16	2	0x188A09C46F1F11206FF9F15CFB5F6CD2F26C4BF485EE37D3650A595064F76CE34E40EAD
81	17	2	0x4B1CDE25539A56CEDC45FE7F54C38CF155F4FB1AE868F6C3952D07014BF828E810BDE2D
82	18	2	0x16CA8F8C6A879E865E3611EAC389D56AFA3E4E84CDBB73567BA4A160249C4B680A7D9BC
83	19	2	0x39D2B08AA0E2E8781476027B41AD72F8D9838B7001AADFD33A92D81E56ECBB2C9378D58
84	20	2	0x8C258BC80D4AD125F335A5151EDF9E9A463E06C5C8D046F82E5DC3D73EF4D2231C5D14F
85	21	2	0x41A029C6356C825585179C5348EDF07A3AC2022539AC28DC4CD3C1DFADC8EE9644CD939
86	22	2	0x0D70A77CBE9804913BFBEC4FBF917C5CD3580F6062BBAD3F99ECEBB4A9EBB87523AB722
87	23	2	0x6A00A30901F9FDE44B4F1ECED44E0BCB943B29519F313BE4496D34F39B154FC2384CB75
88	24	2	0x95351107A8BE6ABFC24C1292FE1A0FE677CBFD04F2E81178CAA9D294730EF9C946F676E
89	25	2	0x01F21470FD9B1E0B3C6B2F7C0412A15764C277D61BA2EE3B3769DE7ADACB2BB29918FB7
90	26	2	0xA578ABFE155369440FA3D4DF757CCA596469B80A0E56BFE6010DD63E67CEDB86BB1EF39
91	27	2	0x1E1CFFAB031836777DE5D168A9246C559574C74CCC06405EB406B8DDB7C9A6EF54A66A5
92	28	2	0x354149C2CA19A735F9CD04AF4922E8ECE6509B978B951F946FD4AD36C7F9C83624205E7

Table BB1—Preamble modulation series per segment and Cell ID

Index	Cell ID	Segment	Series to modulate (W_k)
93	29	2	0x5A27E60DEA547D0D41897A03199F28A967AC51728E3B3 8325B4FBECF1B85A7EE9B04182
94	30	2	0x784DA3B16B810FE3B851060AD7BD27D9D9457F6C8899 A13D311E531B855C15ECE6D3A2F
95	31	2	0xD7DFBC65797633A8C13D3EEC781D48952338136063B579 D69437B28B744B5A4BE18AFA9

9a.4.1.2 CBP preamble

The CBP preamble shall have a duration of 1 OFDM symbol. The PN series modulating the CBP preamble carrier-set is defined in Table H1. The series modulated depends on the segment used and CBP ID parameter. The defined series shall be mapped onto the CBP preamble subcarriers in ascending order. Table H1 includes the PN sequence in a hexadecimal format. The value of the PN is obtained by the same manner as described in 9a.4.1.1.

Table BC1—CBP Preamble modulation series per segment and Cell ID

Index	Cell ID	Segment	Series to modulate (W_k)
0	0	0	0x61AF26BD39A9FFF52826625E04ADA299385A373FA946D 837D754E6CFEBB26F5C03B87CF
1	0	1	0xD77D97CDB93DBEAA65CAFA146F40D72B5E80944F750 E07325DC164ED60F32434BC7187D
2	0	2	0x4529D9CA65AF49C1C39BDC18CFAB87E03FE4DAFC0A4 8FF1457D46B0DF66B414A23ACDDB
3	1	0	0x33AC0261DAA57C1D611EBA1C730D50AFEE5BE3E84903 0A4E891BC8C5F4C78DCDDFEA263
4	1	1	0xBED48C704F02A84F03BCD299D919DA56F7B71EDF8A0F 8A25E8F8496F95A44CE2B9F74C9
5	1	2	0x0ECCBE0902EBF4B4C29506014A3706622784B7B2D5153 E10AD3112DC5E45277A32E79DE
6	2	0	0x7CB4937889C7DFD9AA2D37235E06F993D3D4F5D515B39 CA652F62397C08457D66BC5A36
7	2	1	0x43F23F6CAC6C43896B3EDBF00E1CBD42E2CC75E2A996 448F0FCF17F6779DD6E356FED11

Table BC1—CBP Preamble modulation series per segment and Cell ID

Index	Cell ID	Segment	Series to modulate (W_k)
8	2	2	0x72C8A209FBC4A568BEF03BCFE1B0D959F977B0963780B4E54E2B9A1016344ACB7EE3E3A
9	3	0	0x77AEB9E50DC3727849A94FBFFCDB5B9589AF50ABD8A58808B9663058E17A2EBC496DF43
10	3	1	0x667123C89077FE4AAAEF15C635E976C6811682D478FFC7B721A76B5A38697DF4FB7D2CE
11	3	2	0xCBD6C5C9BE55B0BE76AD03392E8A8AB9A86063DB31B79280B447980BB841FD7E9DC6B9B
12	4	0	0xC7D7DEF8B3C9C8667D8D65063B4DAD1FF69445C87CA71DA955D0CA23970E988A6EA4C83
13	4	1	0xFB246ABD92F9E560CB2BEC2317204C9CE22AD3BD19EA02E90F5F3B7F4F65538D8ED098E
14	4	2	0x29E74579472FDD8FFC2700B2BF33C649989DD8153093A7CA08B50F7A5E4BAED108A0F0D
15	5	0	0xA27F29D8D6CCD7EB4BBE303C3E9E95802DB98BFD5B8ED03B88304359D92E3EC108CA3C8
16	5	1	0x3FE70E26FA00327FE3B2BE6BC5D5014F588F09C17D222C146DD68B4824692A651888C76
17	5	2	0x41E91307EC58801CFF2C7E9CFEFBEB71681FAE2BEAEC72D4E4556E99345D3BA4B369B59

9a.4.2 Control header and MAP definitions

9a.4.2.1 Frame control header (FCH)

The frame control header is transmitted as part of the downstream PDU in the DS subframe. The length of the FCH shall be 3 bytes and contain information as specified in Table 7.5.2a (to be described in MAC section). The FCH shall be sent in the first subchannel of the symbol immediately following the frame preamble symbol. The FCH shall be encoded using QPSK rate 1/2 with four repetitions using the binary convolutional channel coding . The FCH contains the downstream frame prefix as described in 7.5.2a (to be determined in MAC section), and specifies the length of the DS-MAP message that immediately follows the downstream frame prefix and the repetition coding used for the DS-MAP message.

9a.4.2.2 DS-MAP, US-MAP, DCD, and UCD

The length of the DS-MAP PDU is variable and is defined in the FCH (9a.4.2.1). This PDU shall be encoded using the binary convolutional channel coding specified in 9a.7.2.1 and transmitted using the PHY mode 3 listed in Table AZ1 in the logical subchannel immediately following the FCH. The length of the US-MAP, DCD and UCD, when present, shall be specified at the beginning of the DS-MAP in that order. The number of subchannels required to transmit these fields shall be determined by their respective lengths in number of OFDM slots. These fields shall be transmitted using PHY mode 4. If this number exceeds the number of subchannels, the transmission of these PDUs will continue in the next slot starting with the first logical subchannel. The unused subchannels in the last slot of the frame header shall be used for DS transmissions.

9a.5 CBP packet format

The format of the CBP packet is shown in Table BM1. The CBP packet consists of a preamble portion and a data portion. The CBP preamble is one OFDM symbol in duration and is generated as described in 9a.4.1.2. The format of the CBP data portion is the same as the data portion of the normal zone.

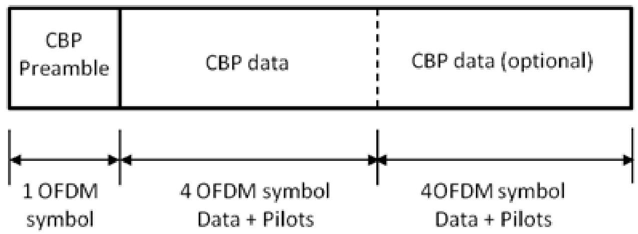

Figure BM1—CBP packet format

9a.6 OFDM subcarrier allocation

Sampling frequencies are F_s =5.6 MHz, 6.53 MHz, and 7.47 MHz for the channel bandwidth of 6 MHz, 7 MHz, and 8 MHz, respectively. Subtracting the guard subcarriers from N_{FFT} (=1024), one obtains the set of used subcarriers which consists of both pilot subcarriers and data subcarriers. In the DS, the pilot subcarriers are allocated first; then data subcarriers are divided into subchannels. In the US, the set of used subcarriers is first partitioned into subchannels, and then the pilot subcarriers are allocated from within each subchannel.

9a.6.1 Pilot pattern

9a.6.1.1 Downstream (DS)

A slot (or a subchannel) in the DS is composed of four (4) OFDMA symbols and 16 subcarriers as shown in Figure BE1 Within each slot, there are 48 data subcarriers and 16 fixed-position pilots. The subchannel is constructed from four (4) DS tiles. Each tile has four successive active subcarriers, and its configuration is illustrated in Figure BN1

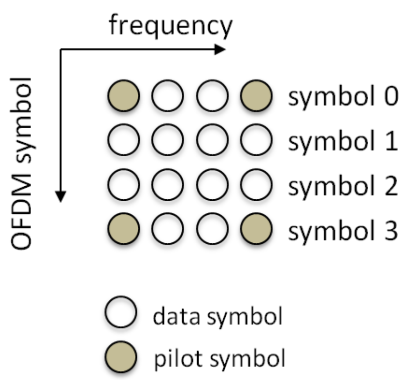

Figure BN1—Pilot pattern for DS

9a.6.1.2 Upstream (US)

A slot (or a subchannel) in the US is composed of seven (7) OFDMA symbols and 8 subcarriers as shown in Figure BF1. Within each slot, there are forty eight (48) data subcarriers and eight (8) fixed-position pilots. The subchannel is constructed from two US tiles. Each tile has four successive active subcarriers, and its configuration is illustrated in Figure BO1.

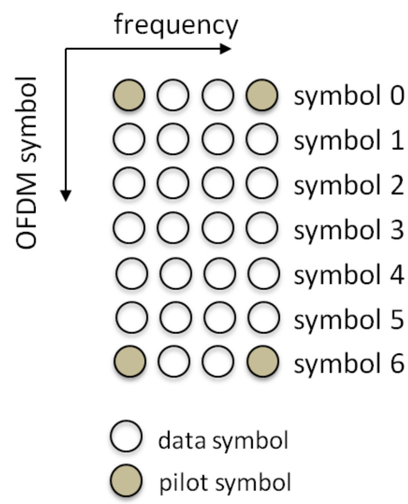

Figure BO1—Pilot pattern for US

9a.6.2 Downstream subcarrier allocation

9a.6.2.1 Symbol structure for subchannel in the downstream

The symbol structure is constructed using pilot, data, and null subcarriers. The symbol is first divided into basic tiles and null carriers are allocated. Pilot and data subcarriers are allocated within each tile. Table BD1 summarizes the parameters of the symbol structure in the downstream (DS).

Table BD1—Symbol structure parameters in the downstream (DS)

Parameters	Value	Comments
FFT size	1024	
Number of DC subcarriers	1	Index 512 (counting from 0)
Number of Guard subcarriers, Left	96	—
Number of Guard subcarriers, Right	95	—
Number of used subcarriers (N_{used})	833	Number of total subcarriers including DC, data and pilot

Table BD1—Symbol structure parameters in the downstream (DS)

Parameters	Value	Comments
Number of subchannels ($N_{subchannels}$)	52	—
Number of tiles (N_{tiles})	208	—
Number of tiles per sub-channel (or slot)	4	—
Number of pilot subcarri-ers per slot	16	—
Number of data subcarri-ers per slot	48	—
Number of OFDM sym-bols per slot	4	—
Number of subcarriers per tile	4	—
Sequence for DS tile per-mutation (P_t)	6, 48, 37, 21, 31, 40, 42, 32, 47, 30, 33, 18, 10, 15, 50, 51, 46, 23, 45, 16, 39, 35, 7, 25, 11, 22, 38, 28, 19, 17, 3, 27, 12, 29, 26, 5, 41, 49, 44, 9, 8, 1, 13, 36, 14, 43, 2, 20, 24, 4,34, 0	used to allocate tiles to subchannel

9a.6.2.2 Subcarrier allocation and data mapping onto subcarriers

The carrier allocation to subchannels is performed using the following procedure:

a) Subcarriers shall be divided into the number of tiles (N_{tiles}) containing 4 adjacent subcarriers each (starting from carrier 0). The number of tiles (N_{tiles}) in the downstream is 208.

b) Logical tiles are mapped to physical tiles in the FFT using Equation (3).

$$Tiles(s, n) = N_{subchannels} \bullet n + (P_t[(s+n) \bmod N_{subchannels}] + \text{DS\_PermBase}) \bmod N_{subchannels} \quad (3)$$

where

— $Tiles(s, n)$ is the physical tile index in the FFT with tiles being ordered consecutively from the most negative to the most positive used subcarrier (0 is the starting tile index)

— n is the tile index 0,1,2,3 in a subchannel

— $N_{subchannels}$ is the number of subchannels: 52

— s is the index number of a subchannel: $0 \ldots N_{subchannels}-1$

— P_t is the sequence for the downstream tile permutation shown below DS_PermBase is an integer ranging from 0 to 31, which is set to preamble-Cell ID in the first zone

—P_t= {6, 48, 37, 21, 31, 40, 42, 32, 47, 30, 33, 18, 10, 15, 50, 51, 46, 23, 45, 16, 39, 35, 7, 25, 11, 22, 38, 28, 19, 17, 3, 27, 12, 29, 26, 5, 41, 49, 44, 9, 8, 1, 13, 36, 14, 43, 2, 20, 24, 4,34, 0}

— DS_PermBase is an integer ranging from 0 to 31, which is set to preamble Cell ID in the first zone.

—Example of the logical tile mapping to the physical tile is provided below to clarify the operation of Equation 9.X.6.3.2-1. In this example, tiles used for subchannel *s* = 2 in DS_PermBase = 1 are computed.

- Apply the permutation due to the selection of the subchannel (*s* = 2), rotate_times: {37, 21, 31, 40, 42, 32, 47, 30, 33, 18, 10, 15, 50, 51, 46, 23, 45, 16, 39, 35, 7, 25, 11, 22, 38, 28, 19, 17, 3, 27, 12, 29, 26, 5, 41, 49, 44, 9, 8, 1, 13, 36, 14, 43, 2, 20, 24, 4,34, 0, 6, 48 }.
- Take the first 4 numbers, and add the DS_PermBase (perform modulo operation if needed): {38, 22, 32, 41}.
- Finally, add the appropriate shift: {38, 74, 136, 197}.

c) After allocating the pilot subcarriers within each tile, indexing of the data subcarriers within each slot is performed starting from the first symbol at the lowest indexed subcarrier of the lowest indexed tile, continuing in an ascending manner through the subcarriers in the same symbol, then going to the next symbol at the lowest indexed data subcarrier, and so on. Data subcarriers shall be indexed from 0 to 47. The indexing of the data subcarriers (48 data subcarriers) in one subchannel in DS is shown in Figure BP1

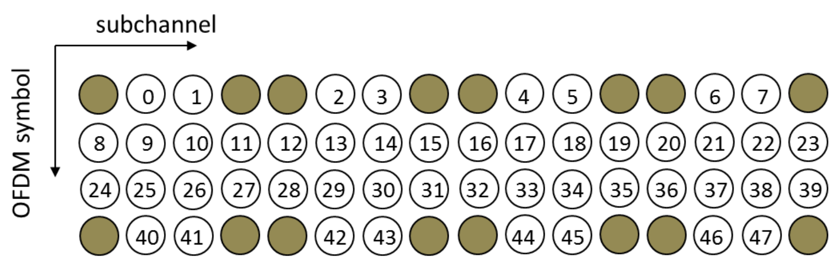

Figure BP1—DS data subcarrier index in one subchannel

d) The mapping of data onto the subcarriers shall follow Equation (4). This equation calculates the subcarrier index to which the data constellation point is to be mapped.

$$Subcarrier(n, s) = (n + 13 \bullet s) \bmod N_{subcarriers} \quad (4)$$

where

— $Subcarrier(n, s)$ is the permutated subcarrier index corresponding to data subcarrier.

— n is a running index 0…47, indicating the data constellation point

— s is the subchannel number 0…51

— $N_{subcarriers}$ is the number of data subcarriers per slot: 48

9a.6.3 Upstream Subcarrier allocation

9a.6.3.1 Symbol structure for subchannel in the upstream

The symbol structure is constructed using pilot, data, and null subcarriers. The symbol is first divided into basic tiles and null carriers are allocated. Pilot and data subcarriers are allocated within each tile. Table BE1 summarizes the parameters of the symbol structure in the upstream (US).

Table BE1—Symbol structure parameters in the upstream (US)

Parameters	Value	Comments
Number of DC subcarriers	1	Index 512 (counting from 0)
Number of Guard subcarriers, Left	92	–
Number of Guard subcarriers, Right	91	–
Number of used subcarriers (N_{used})	841	Number of all subcarriers including DC, data and pilots used within a symbol
Number of subchannels ($N_{subchannels}$)	105	–
Number of tiles (N_{tiles})	210	–
Number of tiles per subchannel	2	–
Number of pilot subcarriers per slot	8	–
Number of data subcarriers per slot	48	–
Number of OFDM symbols per slot	7	–
Number of subcarriers per tile	4	–
Sequence for US tile permutation (P_t)	33, 52, 35, 67, 94, 13, 80, 6, 34, 45, 43, 68, 84, 66, 7, 37, 71, 89, 55, 101, 27, 60, 51, 14, 21, 17, 93, 72, 95, 73, 81, 24, 103, 86, 39, 29, 56, 62, 70, 64, 23, 22, 54, 15, 90, 76, 100, 33, 36, 18, 9, 91, 19, 26, 12, 92, 48, 25, 87, 74, 5, 31, 85, 40, 104, 2, 102, 69, 57, 50, 1, 44, 0, 20, 88, 79, 16, 28, 46, 42, 41, 59, 96, 97, 99, 82, 30, 49, 65, 77, 63, 11, 8, 75, 98, 38, 32, 83, 4, 47, 58, 61, 78, 10, 53	used to allocate tiles to subchannel

9a.6.3.2 Subcarrier allocation and data mapping onto subcarriers

The carrier allocation to subchannels is performed using the following procedure:

a) The usable subcarriers in the allocated frequency band shall be divided into N_{tiles} physical tiles with parameters specified by Table BE1. The number of tiles (N_{tiles}) in the upstream is 210.

b) Logical tiles are mapped to physical tiles in the FFT using Equation (5).

$$Tiles(s, n) = N_{subchannels} \bullet n + (P_t[(s+n) \bmod N_{subchannels}] + \text{US\_PermBase}) \bmod N_{subchannels} \quad (5)$$

where

— $Tiles(s, n)$ is the physical tile index in the FFT with tiles being ordered consecutively from the most negative to the most positive used subcarrier (0 is the starting tile index)

— n is the tile index 0,1 in a subchannel

— $N_{subchannels}$ is the number of subchannels: 105

— s is the index number of a subchannel: $0 \ldots N_{subchannels}-1$

— P_t is the sequence for the upstream tile permutation shown below

—P_t= {33, 52, 35, 67, 94, 13, 80, 6, 34, 45, 43, 68, 84, 66, 7, 37, 71, 89, 55, 101, 27, 60, 51, 14, 21, 17, 93, 72, 95, 73, 81, 24, 103, 86, 39, 29, 56, 62, 70, 64, 23, 22, 54, 15, 90, 76, 100, 33, 36, 18, 9, 91, 19, 26, 12, 92, 48, 25, 87, 74, 5, 31, 85, 40, 104, 2, 102, 69, 57, 50, 1, 44, 0, 20, 88, 79, 16, 28, 46, 42, 41, 59, 96, 97, 99, 82, 30, 49, 65, 77, 63, 11, 8, 75, 98, 38, 32, 83, 4, 47, 58, 61, 78, 10, 53}

— US_PermBase is an integer value which is assigned by a management entity

—Example of the logical tile mapping to the physical tile is provided below to clarify the operation of Equation 9.X.6.3.2-1. In this example, tiles used for subchannel s = 3 in US_PermBase = 2 are computed.

•Apply the permutation due to the selection of the subchannel (s = 3), rotate three times: {67, 94, 13, 80, 6, 34, 45, 43, 68, 84, 66, 7, 37, 71, 89, 55, 101, 27, 60, 51, 14, 21, 17, 93, 72, 95, 73, 81, 24, 103, 86, 39, 29, 56, 62, 70, 64, 23, 22, 54, 15, 90, 76, 100, 33, 36, 18, 9, 91, 19, 26, 12, 92, 48, 25, 87, 74, 5, 31, 85, 40, 104, 2, 102, 69, 57, 50, 1, 44, 0, 20, 88, 79, 16, 28, 46, 42, 41, 59, 96, 97, 99, 82, 30, 49, 65, 77, 63, 11, 8, 75, 98, 38, 32, 83, 4, 47, 58, 61, 78,10, 53, 33, 52, 35}.

•Take the first 2 numbers, and add the US_PermBase (perform modulo operation if needed): {69, 96}.

•Finally, add the appropriate shift: {69, 201}.

c) After allocating the pilot subcarriers within each tile, indexing of the data subcarriers within each slot is performed starting from the first symbol at the lowest indexed subcarrier of the lowest indexed tile, continuing in an ascending manner through the subcarriers in the same symbol, then going to the next symbol at the lowest indexed data subcarrier, and so on. Data subcarriers shall be indexed from 0 to 47. The indexing of the data subcarrier (48 data subcarriers) in one subchannel in US is shown in Figure BQ1.

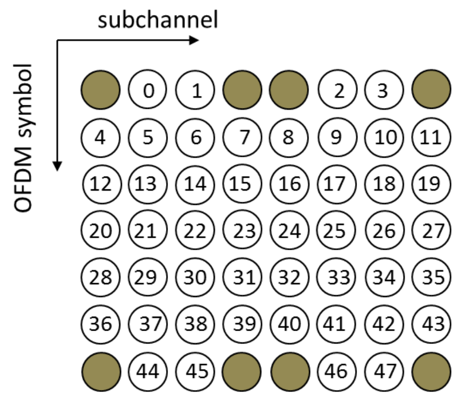

Figure BQ1—US data subcarrier index in one subchannel

d) The mapping of data onto the subcarriers shall follow Equation (6). This equation calculates the subcarrier index to which the data constellation point is to be mapped.

$$Subcarrier(n, s) = (n + 13 \cdot s) \bmod N_{subcarriers} \quad (6)$$

where

— $Subcarrier(n, s)$ is the permutated subcarrier index corresponding to data subcarrier.
— n is a running index 0…47, indicating the data constellation point
— s is the subchannel number 0…104
— $N_{subcarriers}$ is the number of data subcarriers per slot: 48

For example, for subchannel 1 (s = 1), the first data constellation point (n = 0) is mapped onto *Subcarrier* (0,1) = 13, where 13 is the subcarrier with index 13 according to step a) in this subclause. Considering the upstream tile structure (4 subcarriers by 7 OFDM symbols), it can be seen that this is the second indexed subcarrier on the third symbol within the slot.

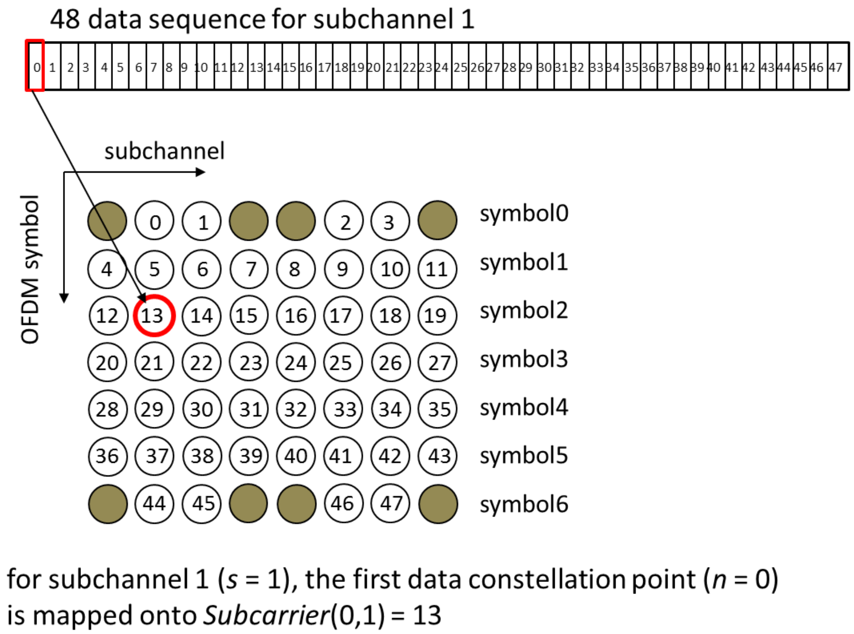

Figure BR1—Example of data mapping onto subcarrier (*s*=1, *n*=0)

Similarly, for subchannel 3, the ninth data constellation point (*n* = 8) is mapped onto *Subcarrier* (8, 3) =47. According to step a), this is the last indexed subcarrier of the seventh symbol within the slot.

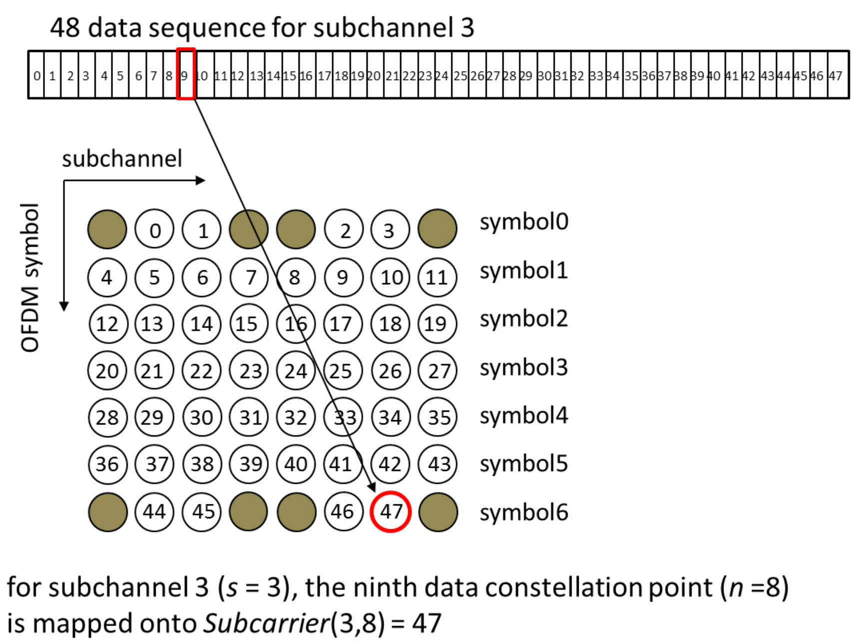

Figure BS1—Example of data mapping onto subcarrier (*s*=3, *n*=8)

9a.6.3.3 Data subchannel rotation scheme

In the upstream, a rotation scheme shall be applied per OFDMA slot duration. On each slot duration, the rotation scheme shall be applied to all US subchannels that belong to the normal data burst. The rotation scheme is defined by applying the following rules:

a) Per OFDMA slot duration, pick the subchannels that are used for the normal data burst. Renumber these subchannels contiguously so that the lowest numbered physical subchannel is renumbered with 0. The total number of subchannels picked shall be designated N_{subchn}.

b) The mapping function defined by rule a) shall define a function, *f*, so that temp1_subchannel_number = *f* (old_subchannel_number).

c) Mark the first US OFDMA slot duration with the slot index $S_{idx} = 0$. Increase S_{idx} by 1 in every slot duration so that subsequent slots are numbered 1, 2, 3..., etc.

d) Apply the following formula:

— temp2_subchannel_number = (temp1_subchannel_number + 13×S_{idx}) mod N_{subchn}

e) To get the new subchannel number, apply the following formula:

— new_subchannel_number = f^{-1}(temp2_subchannel_number), where f^{-1}(.) is the inverse mapping of the mapping defined in rule b).

f) For subchannels that are used for control burst (for the UIUC value less than 14), new_subchannel_number = old_subchannel_number.

g) The new_subchannel_number shall replace the old_subchannel_number in each allocation defined by 9a.1.3.2 data mapping where the new_subchannel_number is the output of the rotation scheme and the old_subchannel_number is the input of the rotation scheme.

9a.6.4 Bit interleaving

All encoded data bits shall be interleaved by a block interleaver with a block size corresponding to the number of coded bits per the encoded block size N_{cbps} (Possible values of N_{cbps} for each MCS are spedified later.) The interleaver is defined by a two-step permutation. The first ensures that adjacent coded bits are mapped onto nonadjacent subcarriers. The second permutation insures that adjacent coded bits are mapped alternately onto less or more significant bits of the constellation, thus avoiding long runs of lowly reliable bits.

Let N_{cpc} be the number of coded bits per subcarrier, i.e., 2, 4, or 6 for QPSK, 16-QAM, or 64-QAM, respectively. Let $s = N_{cpc}/2$. Within a block of N_{cbps} bits at transmission, let k be the index of the coded bit before the first permutation, m_k be the index of that coded bit after the first and before the second permutation and let j_k be the index after the second permutation, just prior to modulation mapping, and d be the modulo used for the permutation.

The first permutation is defined byEquation (7):

$$m_k = (N_{cbps}/d) \cdot k_{mod(d)} + floor(k/d) \quad k = 0, 1, \ldots, N_{cbps} - 1 \quad d = 16 \tag{7}$$

The second permutation is defined by Equation (8).

$$j_k = s \cdot floor(m_k/s) + (m_k + N_{cbps} - floor(d \cdot m_k/N_{cbps}))_{mod(s)} \quad k = 0, 1, \ldots, N_{cbps} - 1 \quad d = 16 \tag{8}$$

The de-interleaver, which performs the inverse operation, is also defined by two permutations. Within a received block of N_{cbps} bits, let j be the index of a received bit before the first permutation; m_j be the index of that bit after the first and before the second permutation; and let k_j be the index of that bit after the second permutation, just prior to delivering the block to the decoder.

The first permutation is defined by Equation (9)).

$$m_j = s \bullet floor(j/\ s) + (j + floor(d \bullet j/\ N_{cbps}))_{mod(s)}\ j = 0, 1, \ldots , N_{cbps} - 1\ d = 16 \quad (9)$$

The second permutation is defined by Equation (10).

$$k_j = d \bullet m_j - (N_{cbps} - 1) \bullet floor(d \bullet m_j / N_{cbps})\ j = 0, 1, \ldots , N_{cbps} - 1\ d = 16 \quad (10)$$

The first permutation in the de-interleaver is the inverse of the second permutation in the interleaver, and conversely.

9a.7 Channel coding

9a.7.2 Forward Error Correction (FEC)

9a.7.2.1 Binary Convolutional code (BCC) mode (mandatory)

9a.7.2.1.3 OFDM slot concatenation

The encoding block size shall depend on the number of OFDMslots allocated and the modulation specified for the current transmission. Concatenation of a number of OFDM slots shall be performed in order to allow for transmission of larger blocks of coding where it is possible, with the limitation of not exceeding the largest block size for the corresponding modulation and coding. Table BF1 specifies the concatenation index for different modulations and coding.

For any modulation and coding, the following parameters are defined:

- j : index dependent on the modulation level and FEC rate
- n : number of allocated OFDM slots
- k : floor (n / j)
- m : n mod j

Table BG1 shows the rules used for OFDM slot concatenation.

Table BF1—Concatenation index for different modulations and coding

Modulation and Rate	j
QPSK 1/2	6
QPSK 2/3	4
QPSK 3/4	4
QPSK 5/6	2
16-QAM 1/2	3
16-QAM 2/3	2
16-QAM 3/4	2

Table BF1—Concatenation index for different modulations and coding

Modulation and Rate	j
16-QAM 5/6	1
64-QAM 1/2	2
64-QAM 2/3	1
64-QAM 3/4	1
64-QAM 5/6	1

Table BG1—OFDM slot concatenation rule

Number of slots	Slots concatenated
$n \le j$	1 block of *n* slots

$n > j$	If (*n* mod *j* = 0) *k* blocks of *j* slots
	else
	(k - 1) blocks of *j* slots
	1 block of ceil ((m + 1) / 2) slots
	1 block of floor ((m + j) / 2) slots

Table BH1defines the basic sizes of the useful data payloads (in bytes) to be encoded in relation with the selected modulation type, encoding rate, and concatenation rule.

Table BH1—Useful data payload for an FEC Block

	QPSK				16-QAM				64-QAM			
Encoding rate	1/2	2/3	3/4	5/6	1/2	2/3	3/4	5/6	1/2	2/3	3/4	5/6

Table BH1—Useful data payload for an FEC Block

	QPSK				16-QAM				64-QAM			
Data Payload (byte)	6											
		8										
			9									
				10								
	12				12							
		16				16						
	18		18				18		18			
				20				20				
	24	24			24					24		
			27								27	
	30											30
		32				32						
	36		36		36		36		36			

9a.8 Constellation mapping and modulation

9a.8.1 Data modulation

9.8.1 provides the details of data modulation. Table 227 in 9.8.1 is changed as Table BI1.

Table BI1—Number of coded bits per OFDM slot (N_{CBPS}) and corresponding number of data bits for different modulation constellation and coding rate combinations

Constellation type	Coding rate	N_{CBPS}	corresponding number of data bits
QPSK	1/2	96	48
QPSK	2/3	96	64
QPSK	3/4	96	72
QPSK	5/6	96	80
16-QAM	1/2	192	96
16-QAM	2/3	192	128

Table BI1—Number of coded bits per OFDM slot (N_{CBPS}) and corresponding number of data bits for different modulation constellation and coding rate combinations

Constellation type	Coding rate	N_{CBPS}	corresponding number of data bits
16-QAM	3/4	192	144
16-QAM	5/6	192	160
64-QAM	1/2	288	144
64-QAM	2/3	288	192
64-QAM	3/4	288	216
64-QAM	5/6	288	240

9a.9 Control mechanisms

9a.9.3 Opportunistic upstream bursts

A ranging channel is composed of one or more groups of six adjacent subchannels, using the symbol structure defined in 9a.6.3.1, where the groups are defined starting from the first subchannel. Subchannels are considered adjacent if they have successive logical subchannel numbers. The indices of the subchannels that compose the ranging channel are specified in the US-MAP message. BS shall allocate ranging, bandwidth (BW) request or UCS notification allocation as a multiple of subchannels.

9a.9.3.1 CDMA bursts

The number of subchannels for the ranging channel and the number of symbols for each transmission (CDMA initial ranging, CDMA periodic ranging, CDMA BW request and CDMA UCS notification) are specified in the US-MAP_IE.

CPEs are allowed to collide on the ranging channel. To still provide reliable transmission, each CPE randomly chooses one ranging code from the subgroup of specified binary codes that is defined in 9a.9.3.1.1. These codes are then BPSK modulated onto the subcarriers in the ranging channel. The length of these binary codes is the same as the number of subcarriers in the ranging channel.

9a.9.3.1.1 CDMA codes

The binary codes shall be the pseudo-noise codes produced by the PRBS generator described in Figure BT1, which illustrates the following polynomial generator: $1+ x^1 + x^4 + x^7 + x^{15}$. The PRBS generator shall be initialized by the seed b15...b1 = 0,0,1,0,1,0,1,1,s0,s1,s2,s3,s4,s5,s6 where s6 is the LSB of the PRBS seed, and s6:s0=US_PermBase, where s6 is the MSB of the US_PermBase.

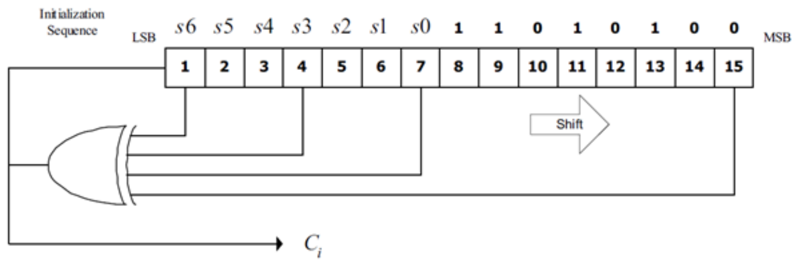

Figure BT1—PRBS generator for ranging code generation

The binary ranging codes shall be subsequences of the pseudo-noise sequence appearing at its output C_i. The length of each ranging code is 144 bits. These bits are used to modulate the subcarriers in a group of six adjacent subchannels. The bits are mapped to the subcarriers in increasing frequency order of the logical subcarriers, such that the lowest indexed bit modulates the subcarrier with the lowest subcarrier index and the highest indexed bit modulates the subcarrier with the highest index. The index of the lowest numbered subchannel in the six shall be an integer multiple of six.

For example, the first 144 bit obtained by clocking the PN generator as specified and by setting US_PermBase = 0, the first code shall be 00110000010001... The next ranging code is produced by taking the output of the 145th to 288th clock of the PRBS generator, etc.

The number of available codes is 256, numbered 0...255. Each BS uses a subset of these codes, where the subgroup is defined by a number S, $0<S<255$. The group of codes shall be between S and $(S+O+N+M+L)$ mod 256

— The first N codes produced are for initial ranging. Clock the PRBS generator 144 × (S mod 256) times to 144 × (($S + N$) mod 256) – 1 times.

— The next M codes produced are for periodic ranging. Clock the PRBS generator 144 × (($N + S$) mod 256) times to 144 × (($N + M + S$) mod 256) – 1 times.

— The next L codes produced are for BW request. Clock the PRBS generator 144 × (($N + M + S$) mod 256) times to 144 × (($N + M + L + S$) mod 256) – 1 times.

— The next O codes produced are for UCS notification. Clock the PRBS generator 144 × (($N + M + L + S$) mod 256) times to 144 × (($N + M + L + O + S$) mod 256) – 1 times.

The BS shall separate colliding codes and extract timing (ranging) and power information by using a correlation function. The time (ranging) and power measurements shall be used by the system to compensate for the various BS-CPE-BS propagation distances. In the process of CPE code detection, the BS will also get the Channel Impulse Response (CIR) for the transmission link from the specific CPE. The precise timing offset shall be estimated by terrestrial ranging (see 10.5.2).

9a.9.3.1.2 Initial-ranging transmission

The initial ranging transmission shall be used by all CPEs to synchronize to the system when attempting to associate. The initial ranging transmission will be used for detecting and adjusting the timing offset and adjusting the transmission EIRP level. The initial-ranging transmission is performed using two or four consecutive symbols starting, as indicated in the US-MAP for the CPE, on the first symbol after the TTG.

These symbols shall be generated according to Equation (11), except that $0 \le t \le 2T_s$. A time-domain illustration used for the initial-ranging transmission is shown in Figure BU1.

$$s(t) = \mathrm{Re}\left\{ e^{j2\pi f_c t} \sum_{k=-\frac{N_{used}-1}{2},k\neq 0}^{\frac{N_{used}-1}{2}} c_k \cdot e^{j2\pi k \Delta f (t-T_g)} \right\} \quad (11)$$

where

— t is the time, elapsed since the beginning of the subject OFDMA symbol

— c_k is a complex number; the data to be transmitted on the subcarrier whose frequency offset index is k, during the subject OFDMA symbol. It specifies a point in a QAM constellation

— T_g is the guard time

— T_s is the OFDMA symbol duration, including guard time

— Δf is the subcarrier frequency spacing

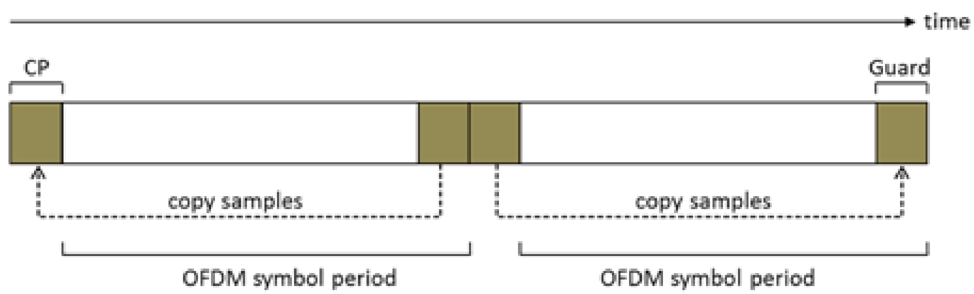

Figure BU1—Initial-ranging transmission

The BS can allocate two consecutive initial ranging slots; onto those slots, the CPE shall transmit the two consecutive initial ranging codes (starting code shall always be a multiple of 2), as illustrated in Figure BV1.

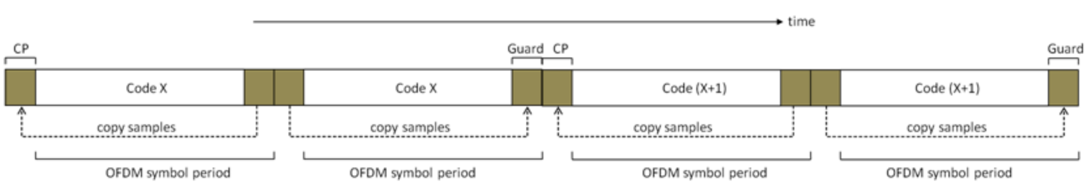

Figure BV1—Initial-ranging transmission, using two consective initial ranging codes

9a.9.3.1.3 CDMA periodic-ranging, BW-request, and UCS notification transmission

Periodic-ranging transmissions shall be sent periodically by CPEs identified by the BS for system periodic ranging. Bandwidth-request transmissions shall be for requesting upstream allocations from the BS. UCS notification transmissions shall be used for reporting detection of an incumbent. These transmissions shall be sent only by CPEs that have already associated with the base station. To perform periodic-ranging, bandwidth-request or UCS notification transmission, the CPE can send a transmission in one of the following manners.

a) Modulate one ranging code on the ranging subchannel for a period of one OFDM symbol. Ranging subchannels shall be dynamically allocated by the MAC layer at the BS and indicated by the number of subchannels in the US-MAP_IE. A time domain illustration of the periodic-ranging, bandwidth-request or UCS notification transmission is shown in Figure BW1

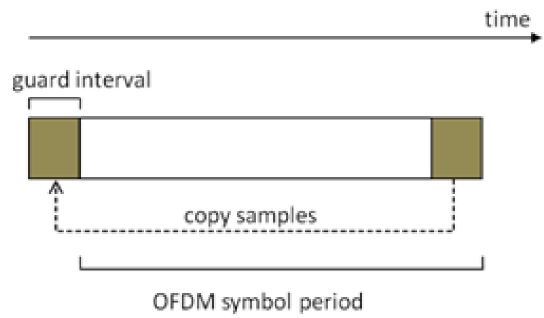

Figure BW1—Periodic-ranging/Bandwidth-request/UCS notification transmission using one code

b) Modulating three consecutive ranging codes (starting code shall always be a multiple of three) on the ranging subchannel for a period of three OFDMA symbols (one code per symbol). Ranging subchannels are dynamically allocated by the MAC and indicated in the US-MAP. A time-domain illustration of the periodic ranging, BW-request, or UCS notification transmission is shown in Figure BX1.

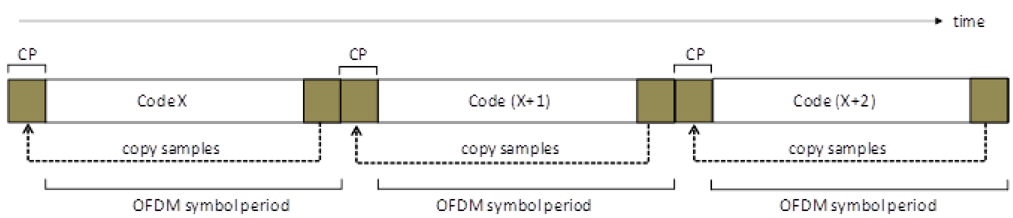

Figure BX1—Periodic-ranging/Bandwidth-request/UCS notification transmission using three consecutive codes

9a.9.3.1.4 Ranging, BW request, and UCS notification opportunity windows

For CDMA ranging, BW-request and UCS notification transmission, the ranging opportunity size is the number of symbols required to transmit the appropriate ranging/BW-request/UCS notification code (1, 2, 3, or 4 symbols), and is denoted N_1. N_2 denotes the number of subchannels required to transmit a ranging code. In each allocation of ranging/BW-request/UCS notification, the opportunity size (N_1) is fixed and conveyed by the corresponding US-MAP IE that defines the allocation.

The ranging allocation is subdivided into slots of N_1 OFDMA symbols by N_2 subchannels, in a time first order, i.e., the first opportunity begins on the first symbol of the first subchannel of the ranging allocation, the next opportunities appear in ascending order in the same subchannel, until the end of the ranging/BW-request/UCS notification (or until there are less than N_1 symbols in the current subchannel), and then the number of subchannel is incremented by N_2. The ranging allocation is not required to be a whole multiple of N_1 symbols, so a gap may be formed (that can be used to mitigate interference between ranging and data transmissions). Each CDMA code shall be transmitted at the beginning of the corresponding slot. See Figure BY1

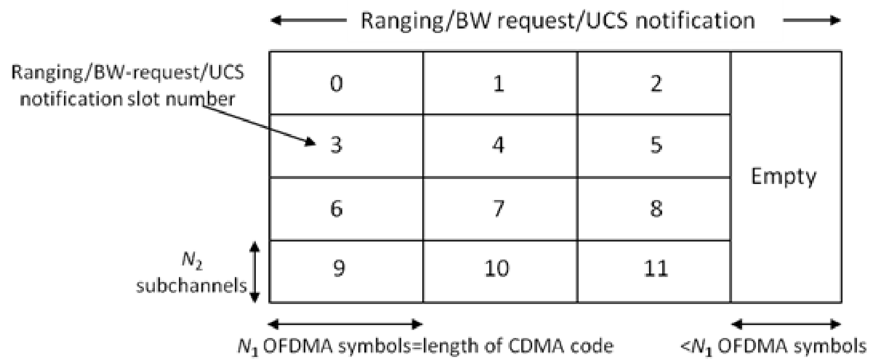

Figure BY1—Example of Ranging/BW request/UCS notification opportunities windowsCognitive radio capability

9.2 General

Insert the following paragraph as the end of 9.2:

IEEE 802.22b devices shall employ the cognitive radio capabilityrequired by regulatory.

10. Configuration

11. Parameters and connection management

12. MIB structure

13. Multiple-input, multiple-output (MIMO)

13.1 MIMO channel estimation and synchronization

13.1.1 MIMO pilot allocation

When using MIMO scheme for PHY Mode 2, the data allocation to tile is changed to accommodate multiple antennas transmission for the channel estimation. MIMO pilot allocations for the cases of 2 TX antennas and 4 TX antennas are described in 13.1.1.1 and 13.1.1.2, respectively. Each subsection includes both DS and US pilot allocations for multiple transmit antennas.

13.1.1.1 Pilot allocation for 2 antennas

In the case of two (2) transmit BS antennas, the DS data allocation to tile is changed (Figure BZ1) to accommodate two antennas transmission for channel estimation. Figure BZ1 replaces Figure BN1 in 9a.6.1.1 when MIMO is enabled.

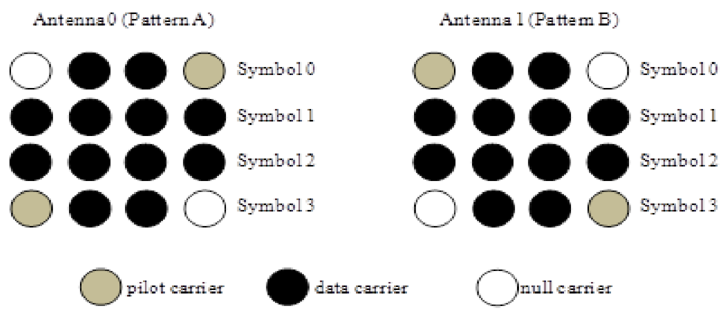

Figure BZ1—DS tile structure for 2 TX antennas

In the case of two (2) transmit CPE antennas, the US data allocation to tile is changed (Figure CA1) to accommodate two antennas transmission for channel estimation. Figure CA1 replaces Figure BO1 in 9a.6.1.2 when MIMO is enabled.

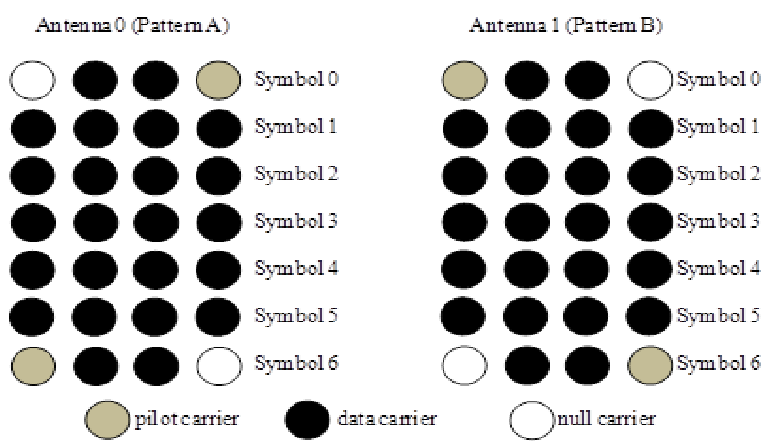

Figure CA1—US tile structure for 2 TX antennas

13.1.1.2 Pilot allocation for 4 antennas

In the case of four (4) transmit BS antennas, the DS data allocation to tile is changed (Figure CB1) to accommodate four antennas transmission for channel estimation. Figure CB1 replaces Figure BN1 in 9a.6.1.1 when MIMO is enabled.

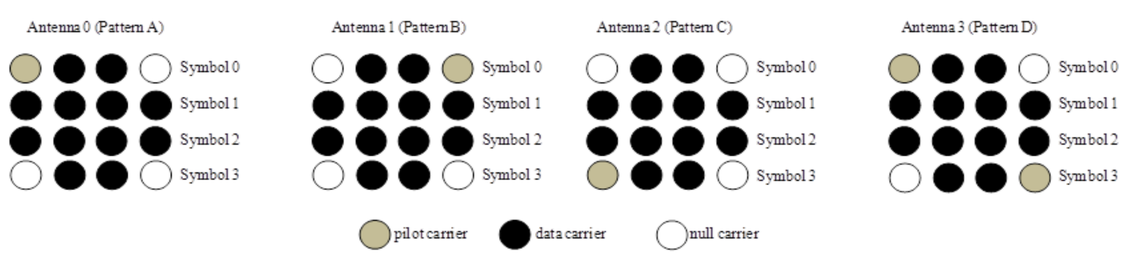

Figure CB1—DS Tile structure for 4 TX antennas

In the case of four (4) transmit CPE antennas, the US data allocation to tile is changed (Figure CC1) to accommodate four antennas transmission for channel estimation. Figure CC1 replaces Figure BO1 in 9a.6.1.2 when MIMO is enabled.

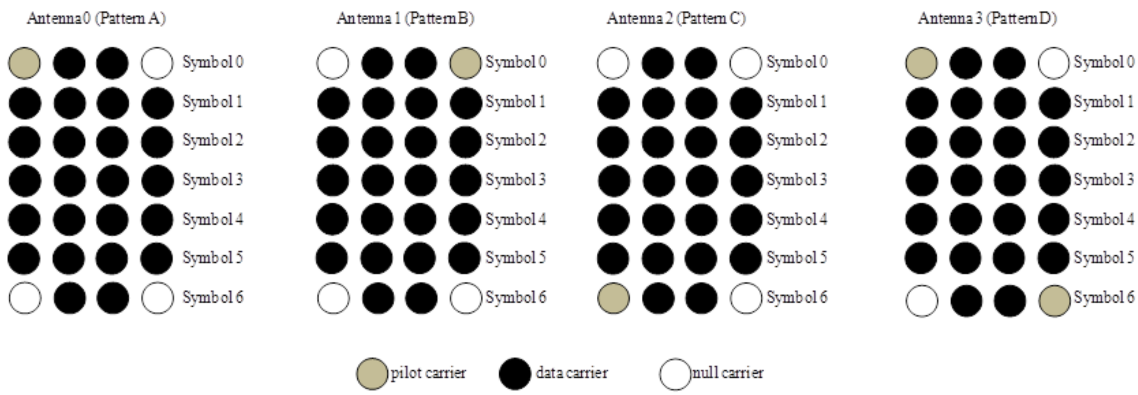

Figure CC1—US tile structure for 4 TX antennas

13.2 Space Time Coding (STC)

13.2.1 Transmit diversity using 2 antennas (Alamouti O-STBC)

TBD

13.2.2 Transmit Diversity with Array-Interference Gain

The technique disclosed in this subsection is full rate based on array-interference constructive aggregation. Its objective is to improve the link reliability over conventional transmit diversity, i.e., Space-Time Block Codes (STBC). This technique intentionally creates aligned array interference so as to exploit its energy in the form of added array gain. As a result, the overall gain (diversity gain + array gain) reduces the bit-error probability (BEP) as compared to the diversity gain only yielded by conventional STBC [1], [2] based systems.

13.2.2.1 Transmit Diversity with Array-Interference Gain for 2 antennas

In this subsection we describe the structure of a 2 transmit (TX) antennas ($n_t = 2$) transmit diversity TDD system exploiting transmit array interference. Since the system is based on TDD, both transmitter and receiver operate in the same frequency channel, however, in different time-slots. In addition, in a communication system, transmitter and receiver alternate their roles, i.e., the transmitter in time "T_n" is the receiver in the consecutive time "T_{n+1}". A direct consequence of the aforementioned, is that both transmitter and receiver can estimate the wireless channel **H** during the time in each they are acting as receiver.

The vector $\mathbf{H} = [h_1\ h_2]$ represents the multiple-input-single-output (MISO) channel between the base station and the single antennae receiver (RX) white space device. In the analyses presented hereafter, **H** is considered to be quasi-static.

Symbols vectors are transmitted through **H** and noise is added at the receiver as shown in Fig. 1. The transmitter is composed of two blocks, namely, 'array gain maximization' and 'transmit vector selector'. On the other hand, the receiver is composed of the blocks “channel estimator”, “combiner”, “array gain maximization” and “ML detection” in order to recover the transmitted symbols, however, with array-interference gain. The aforementioned blocks are described in the following subsections.

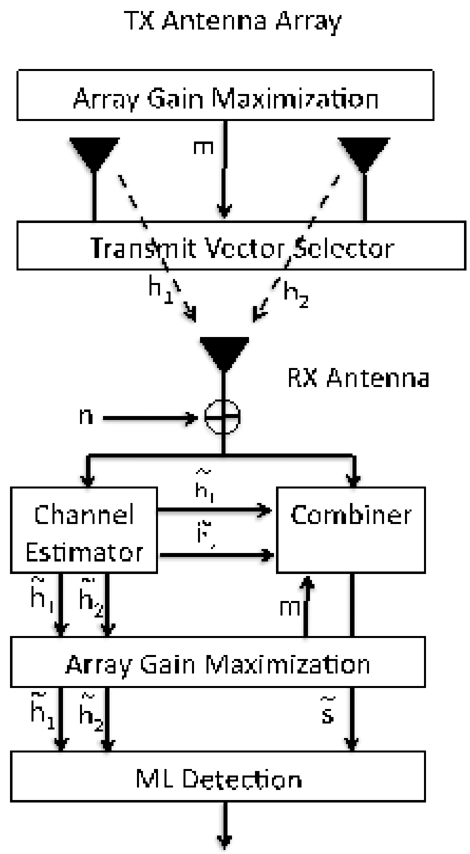

Figure CD1—Transmit Diversity with Array-Interference Gain for 2 TX Antennas

In 2 TX antennas systems, a total of two unique transmit vectors G_m, for $m \in \{0,1\}$ exists. As it will be explained in the following, each G_m yields a single interference, which is aligned to the original signal thus improving system robustness towards fading. The total interference has components coming from all antennas in the array thus it is hereafter called aligned array interference I_{Am}. It should be noted that I_{Am}, where $m \in \{0,1\}$, are functions of the fading channel **H**, and both TX and RX can estimate **H** due to the duality of up-link/down-link. Consequently, I_{Am} can be calculated beforehand and stored in RX device memory.

The ‘channel estimator’ block performs channel estimation based on pilots. The estimation is then provided to the ‘combiner’ block and the ‘array gain maximization’ block.

Both “Array Gain Maximization” blocks in TX and RX, perform

$$\arg\max_{m}(I_{Am}), \forall m \in \{0,1\}$$

in order to compare all the I_{Am} and selects the one that has the maximum value.

Following, the “array gain maximization” block at the transmitter sends *m* inherent to the maximum array interference to the “transmit vector selector” block, which selects G_m to be transmitted over the channel **H** since G_m will yield the maximum array gain. In addition, “the array gain maximization” block at the receiver sends the index *m*, in binary, to the ‘combiner’ block, which is collocated in the same RX device. For instance, if *m* = ‘1’, the ‘combiner’ block will utilize the weight w_1, when it receives the signal from TX.

The ‘combiner block’ provides symbol estimate to the ‘maximum likelihood (ML) detector’ block.

Array Gain Maximization Block

In the array gain maximization block, the array interference I_{Am} is stored as a function of **H.**

— Array Interference I_{A0}

$$I_{A0} = h_1^* h_2 + h_1 h_2^*$$

— Array Interference I_{A1}

$$I_{A1} = -h_1^* h_2 - h_1 h_2^*$$

In order to select the most aligned interference, the ‘array gain maximization’ block performs

$$\arg\max_m (I_{Am}), \forall m \in \{0,1\}$$

The ‘array gain maximization’ block at the TX directly sends *m* to the collocated ‘transmit vector selector’ while the ‘array gain maximization’ block at the receiver sends *m* to the collocated ‘combiner block’. For the following implementation examples consider that *m* is represented by 3 bits.

Combiner Block

Let $H = [h_1 \; h_2]$ and ^{T} denotes transpose operation and *n*, the zero-mean additive white Gaussian noise (AWGN).

— If the ‘combiner’ block receives *m = 000* from the ‘array gain maximization’ block, the received signal is

$$y = G_0 \cdot H^T + n$$

.

The combiner, then, utilizes

$$w_0 = [\;1 \;\; 1]$$

for the combination. However, for the specific case of m = 000, multiplying vector w_m is not necessary and left here for illustration purposes only. The ‘combiner’ block performs the following combination,

$$\tilde{S} = yH^* \cdot w_0^T$$

$$\tilde{S} = y[h_1^* h_2^*] \cdot \begin{pmatrix} 1 \\ 1 \end{pmatrix}$$

$$\tilde{S} = S(|h_1|^2 + |h_2|^2) + S(h_1^* h_2 + h_1 h_2^*) + nh_1^* + nh_2^*$$

,

which is, then, passed to the MML detector to perform the symbol estimation.

— If the 'combiner' block receives m = 001, then,

$$y = G_1 \cdot H^T + n$$

The combiner, then, utilizes

$$w_1 = [\ 1\ \text{-}1]$$

yielding,

$$\tilde{S} = yH^* \cdot w_1^T$$

$$\tilde{S} = y[h_1^* h_2^*] \cdot \begin{pmatrix} 1 \\ \text{-}1 \end{pmatrix}$$

$$\tilde{S} = S(|h_1|^2 + |h_2|^2) + S(-h_1^* h_2 - h_1 h_2^*) + nh_1^* - nh_2^*$$

This is, then, passed to the MML detector to perform the symbol estimation.

13.2.2.2 Transmit Diversity with Array-Interference Gain for 4 antennas

Array Gain Maximization Block

In the case of 4 TX antennas, there are eight unique G_m together with their respective I_{Am} as well as w_m, m $\in$ {0,1,2,3,4,5,6,7}.

$$I_{A0} = h_1^* h_2 + h_1 h_2^* + h_1^* h_3 + h_1 h_3^* + h_1^* h_4 + h_1 h_4^* + h_2^* h_3 + h_2 h_3^* + h_2^* h_4 + h_2 h_4^* + h_3^* h_4 + h_3 h_4^*$$

$$I_{A1} = -h_1^* h_2 - h_1 h_2^* - h_1^* h_4 - h_1 h_4^* - h_2^* h_3 - h_2 h_3^* - h_3^* h_4 - h_3 h_4^* + h_1^* h_3 + h_1 h_3^* + h_2^* h_4 + h_2 h_4^*$$

$$I_{A2} = -h_1^* h_3 - h_1 h_3^* - h_1^* h_4 - h_1 h_4^* - h_2^* h_3 - h_2 h_3^* - h_2^* h_4 - h_2 h_4^* + h_1^* h_2 + h_1 h_2^* + h_3^* h_4 + h_3 h_4^*$$

$$I_{A3} = -h_1^* h_2 - h_1 h_2^* - h_1^* h_3 - h_1 h_3^* - h_2^* h_4 - h_2 h_4^* - h_3^* h_4 - h_3 h_4^* + h_1^* h_4 + h_1 h_4^* + h_2^* h_3 + h_2 h_3^*$$

$$I_{A4} = -h_1^* h_4 - h_1 h_4^* - h_2^* h_4 - h_2 h_4^* - h_3^* h_4 - h_3 h_4^* + h_1^* h_2 + h_1 h_2^* + h_1^* h_3 + h_1 h_3^* + h_2^* h_3 + h_2 h_3^*$$

$$I_{A5} = -h_1^* h_3 - h_1 h_3^* - h_2^* h_3 - h_2 h_3^* - h_3^* h_4 - h_3 h_4^* + h_1^* h_2 + h_1 h_2^* + h_1^* h_4 + h_1 h_4^* + h_2^* h_4 + h_2 h_4^*$$

$$I_{A6} = -h_1^* h_2 - h_1 h_2^* - h_2^* h_3 - h_2 h_3^* - h_2^* h_4 - h_2 h_4^* + h_1^* h_3 + h_1 h_3^* + h_1^* h_4 + h_1 h_4^* + h_3^* h_4 + h_3 h_4^*$$

$$I_{A7} = -h_1^* h_2 - h_1 h_2^* - h_1^* h_3 - h_1 h_3^* - h_1^* h_4 - h_1 h_4^* + h_2^* h_3 + h_2 h_3^* + h_2^* h_4 + h_2 h_4^* + h_3^* h_4 + h_3 h_4^*$$

In order to select the most aligned interference, the 'array gain maximization' block performs,

$$\arg\max_m (I_{Am}), \forall m \in \{0,1,2,3,4,5,6,7\}$$

The 'array gain maximization' block at the transmitter sends *m* to the 'transmit vector selector' block collocated at the transmitter while the 'array gain maximization' block at the receiver sends *m* to the 'combiner' block collocated at the receiver.

Transmit Vector Selector Block

Transmit $G_0 = [\text{s s s s}]$ if *m* is ‘000’;

Transmit $G_1 = [\text{s -s s -s}]$ if *m* is ‘001’;

Transmit $G_2 = [\text{s s -s -s}]$ if *m* is ‘010’;

Transmit $G_3 = [\text{s -s -s s}]$ if *m* is ‘011’;

Transmit $G_4 = [\text{s s s -s}]$ if *m* is ‘100’;

Transmit $G_5 = [\text{s s -s s}]$ if m is ‘101’;

Transmit $G_6 = [\text{s -s s s}]$ if *m* is ‘110’;

Transmit $G|_7 = [\text{-s s s s}]$ if *m* is ‘111’;

Combiner Block

Let $H = [\text{h}_1\ \text{h}_2\ \text{h}_3\ \text{h}_4]$ and for the sake of simplicity in the example, the channel estimation be perfect, i.e., $\tilde{H} = H$.

— If the ‘combiner’ block receives m = 000 from the ‘array gain maximization’ block, it utilizes $w_0 = [\ 1\ 1\ 1\ 1]$ to perform the combination

$$\tilde{S} = yH^* \cdot w_0^T$$

$$\tilde{S} = y[h_1^* h_2^* h_3^* h_4^*] \cdot \begin{pmatrix} 1 \\ 1 \\ 1 \\ 1 \end{pmatrix}$$

$$\tilde{S} = S(|h_1|^2 + |h_2|^2 + |h_3|^2 + |h_4|^2) + S(h_1^* h_2 + h_1 h_2^* + h_1^* h_3 + h_1 h_3^* + h_1^* h_4 + h_1 h_4^* + h_2^* h_3 + h_2 h_3^* + h_2^* h_4 + h_2 h_4^* + h_3^* h_4 + h_3 h_4^*) + nh_1^* + nh_2^* + nh_3^* + nh_4^*$$

which is, then, passed to the MML detector to perform the symbol estimation.

— If the ‘combiner’ block receives m = 001 from the ‘array gain maximization’ block, it utilizes $w_1 = [\ 1\ \text{-1}\ \ 1\ \text{-1}]$ and performs the following combination,

$$\tilde{S} = yH^* \cdot w_1^T$$

$$\tilde{S} = y[h_1^* h_2^* h_3^* h_4^*] \cdot \begin{pmatrix} 1 \\ -1 \\ 1 \\ -1 \end{pmatrix}$$

$$\tilde{S} = S(|h_1|^2 + |h_2|^2 + |h_3|^2 + |h_4|^2) + S(-h_1^* h_2 - h_1 h_2^* - h_1^* h_4 - h_1 h_4^* - h_2^* h_3 - h_2 h_3^* - h_3^* h_4 - h_3 h_4^* + h_1^* h_3 + h_1 h_3^* + h_2^* h_4 + h_2 h_4^*) + nh_1^* - nh_2^* + nh_3^* - nh_4^*$$

— If the ‘combiner’ block receives m = 010 from the ‘array gain maximization’ block, it utilizes $w_2 = [\,1 \;\; 1 \; -1 \; -1\,]$ and performs the following combination,

$$\tilde{S} = yH^* \cdot w_2^T$$

$$\tilde{S} = y[h_1^* h_2^* h_3^* h_4^*] \cdot \begin{pmatrix} 1 \\ 1 \\ -1 \\ -1 \end{pmatrix}$$

$$\tilde{S} = S(|h_1|^2 + |h_2|^2 + |h_3|^2 + |h_4|^2) + S(-h_1^* h_3 - h_1 h_3^* - h_1^* h_4 - h_1 h_4^* - h_2^* h_3 - h_2 h_3^* - h_2^* h_4 - h_2 h_4^* + h_1^* h_2 + h_1 h_2^* + h_3^* h_4 + h_3 h_4^*) + nh_1^* + nh_2^* - nh_3^* - nh_4^*$$

which is, then, passed to the MML detector to perform the symbol estimation.

— If the ‘combiner’ block receives m = 011 from the ‘array gain maximization’ block, it utilizes $w_3 = [\,1 \; -1 \; -1 \;\; 1\,]$ and performs the following combination,

$$\tilde{S} = yH^* \cdot w_3^T$$

$$\tilde{S} = y[h_1^* h_2^* h_3^* h_4^*] \cdot \begin{pmatrix} 1 \\ -1 \\ -1 \\ 1 \end{pmatrix}$$

$$\tilde{S} = S(|h_1|^2 + |h_2|^2 + |h_3|^2 + |h_4|^2) + S(-h_1^* h_2 - h_1 h_2^* - h_1^* h_3 - h_1 h_3^* - h_2^* h_4 - h_2 h_4^* - h_3^* h_4 - h_3 h_4^* + h_1^* h_4 + h_1 h_4^* + h_2^* h_3 + h_2 h_3^*) + nh_1^* - nh_2^* - nh_3^* + nh_4^*$$

which is, then, passed to the MML detector to perform the symbol estimation.

— If the ‘combiner’ block receives m = 100 from the ‘array gain maximization’ block, it utilizes $w_4 = [\,1 \;\; 1 \;\; 1 \; -1\,]$ and performs the following combination,

$$\tilde{S} = yH^* \cdot w_4^T$$

$$\tilde{S} = y[h_1^* h_2^* h_3^* h_4^*] \cdot \begin{pmatrix} 1 \\ 1 \\ 1 \\ -1 \end{pmatrix}$$

$$\tilde{S} = S(|h_1|^2 + |h_2|^2 + |h_3|^2 + |h_4|^2) + S(-h_1^* h_4 - h_1 h_4^* - h_2^* h_4 - h_2 h_4^* - h_3^* h_4 - h_3 h_4^* + h_1^* h_2 + h_1 h_2^* + h_1^* h_3 + h_1 h_3^* + h_2^* h_3 + h_2 h_3^*) + nh_1^* + nh_2^* + nh_3^* - nh_4^*$$

which is, then, passed to the MML detector to perform the symbol estimation.

— If the ‘combiner’ block receives m = 101 from the ‘array gain maximization’ block, it utilizes $w_5 = [\,1 \;\; 1 \; -1 \;\; 1\,]$ and performs the following combination,

$$\tilde{S} = yH^* \cdot w_5^T$$

$$\tilde{S} = y[h_1^* h_2^* h_3^* h_4^*] \cdot \begin{pmatrix} 1 \\ 1 \\ -1 \\ 1 \end{pmatrix}$$

$$\tilde{S} = S(|h_1|^2 + |h_2|^2 + |h_3|^2 + |h_4|^2) + S(-h_1^* h_3 - h_1 h_3^* - h_2^* h_3 - h_2 h_3^* - h_3^* h_4 - h_3 h_4^* + h_1^* h_2 + h_1 h_2^* + h_1^* h_4 + h_1 h_4^* + h_2^* h_4 + h_2 h_4^*) + nh_1^* + nh_2^* - nh_3^* + nh_4^*$$

which is, then, passed to the MML detector to perform the symbol estimation.

— If the ‘combiner’ block receives m = 110 from the ‘array gain maximization’ block, it utilizes $w_6 = [\,1 \; -1 \;\; 1 \;\; 1\,]$ and performs the following combination,

$$\tilde{S} = yH^* \cdot w_6^T$$

$$\tilde{S} = y[h_1^* h_2^* h_3^* h_4^*] \cdot \begin{pmatrix} 1 \\ -1 \\ 1 \\ 1 \end{pmatrix}$$

$$\tilde{S} = S(|h_1|^2 + |h_2|^2 + |h_3|^2 + |h_4|^2) + S(-h_1^* h_2 - h_1 h_2^* - h_2^* h_3 - h_2 h_3^* - h_2^* h_4 - h_2 h_4^* + h_1^* h_3 + h_1 h_3^* + h_1^* h_4 + h_1 h_4^* + h_3^* h_4 + h_3 h_4^*) + nh_1^* - nh_2^* + nh_3^* + nh_4^*$$

which is, then, passed to the MML detector to perform the symbol estimation.

— If the ‘combiner’ block receives m = 111 from the ‘array gain maximization’ block, it utilizes $w_7 = [-1 \;\; 1 \;\; 1 \;\; 1\,]$ and performs the following combination,

$$\tilde{S} = yH^* \cdot w_7^T$$

$$\tilde{S} = y[h_1^* h_2^* h_3^* h_4^*] \cdot \begin{pmatrix} -1 \\ 1 \\ 1 \\ 1 \end{pmatrix}$$

$$\tilde{S} = S(|h_1|^2 + |h_2|^2 + |h_3|^2 + |h_4|^2) + S(-h_1^* h_2 - h_1 h_2^* - h_1^* h_3 - h_1 h_3^* - h_1^* h_4 - h_1 h_4^* + h_2^* h_3 + h_2 h_3^* + h_2^* h_4 + h_2 h_4^* + h_3^* h_4 + h_3 h_4^*) - nh_1^* + nh_2^* + nh_3^* + nh_4^*$$

The above procedure describes how to obtain diversity added with array gain for systems with multiple antennas at the transmitter, however, with single antenna at the receiver. Bellow, extension to system configuration consisting of multiple receiving antennas is presented.

If more than one antenna is available in the receiver terminal, maximum ratio combining (MRC) can be utilized to significantly enhance link reliability. For simplicity, in the following example consider that the number of antennas available at the receiver is 2. The technique, however, can be utilized for any number of receive antennas.

In order to use MRC, little modification is necessary to what has been presented. The 'Array Gain Maximization' block, now, performs

$$\arg\max_m (I_{Am} + I'_{Am}), \forall m \in \{0,1\}$$

for 2 TX antennas, and

$$\arg\max_m (I_{Am} + I'_{Am}), \forall m \in \{0,1,2,3,4,5,6,7\}$$

for 4 TX antennas. Here, I_{Am} is the array interference in the first RX antenna, given in the previous sections and I'_{Am} represents the array interferences in the second RX antenna. Since the channel to the second RX antenna is given by $\mathbf{H} = [h_3\ h_4]$, for two TX antennas, and $\mathbf{H} = [h_5\ h_6\ h_7\ h_8]$, for 4 TX antennas, I'_{Am} becomes

$$I_{A0} = h_3^* h_4 + h_3 h_4^*$$

$$I_{A1} = -h_3^* h_4 - h_3 h_4^*$$

or

$$I_{A0} = h_5^* h_6 + h_5 h_6^* + h_5^* h_7 + h_5 h_7^* + h_5^* h_8 + h_5 h_8^* + h_6^* h_7 + h_6 h_7^* + h_6^* h_8 + h_6 h_8^* + h_7^* h_8 + h_7 h_8^*$$

$$I_{A1} = -h_5^* h_6 - h_5 h_6^* - h_5^* h_8 - h_5 h_8^* - h_6^* h_7 - h_6 h_7^* - h_7^* h_8 - h_7 h_8^* + h_5^* h_7 + h_5 h_7^* + h_6^* h_8 + h_6 h_8^*$$

$$I_{A2} = -h_5^* h_7 - h_5 h_7^* - h_5^* h_8 - h_5 h_8^* - h_6^* h_7 - h_6 h_7^* - h_6^* h_8 - h_6 h_8^* + h_5^* h_6 + h_5 h_6^* + h_7^* h_8 + h_7 h_8^*$$

$$I_{A3} = -h_5^* h_6 - h_5 h_6^* - h_5^* h_7 - h_5 h_7^* - h_6^* h_8 - h_6 h_8^* - h_7^* h_8 - h_7 h_8^* + h_5^* h_8 + h_5 h_8^* + h_6^* h_7 + h_6 h_7^*$$

$$I_{A4} = -h_5^* h_8 - h_5 h_8^* - h_6^* h_8 - h_6 h_8^* - h_7^* h_8 - h_7 h_8^* + h_5^* h_6 + h_5 h_6^* + h_5^* h_7 + h_5 h_7^* + h_6^* h_7 + h_6 h_7^*$$

$$I_{A5} = -h_5^* h_7 - h_5 h_7^* - h_6^* h_7 - h_6 h_7^* - h_7^* h_8 - h_7 h_8^* + h_5^* h_6 + h_5 h_6^* + h_5^* h_8 + h_5 h_8^* + h_6^* h_8 + h_6 h_8^*$$

$$I_{A6} = -h_5^* h_6 - h_5 h_6^* - h_6^* h_7 - h_6 h_7^* - h_6^* h_8 - h_6 h_8^* + h_5^* h_7 + h_5 h_7^* + h_5^* h_8 + h_5 h_8^* + h_7^* h_8 + h_7 h_8^*$$

$$I_{A7} = -h_5^* h_6 - h_5 h_6^* - h_5^* h_7 - h_5 h_7^* - h_5^* h_8 - h_5 h_8^* + h_6^* h_7 + h_6 h_7^* + h_6^* h_8 + h_6 h_8^* + h_7^* h_8 + h_7 h_8^*$$.

The ‘array gain maximization’ block at the transmitter sends *m* to the collocated ‘transmit vector selector’ block while the ‘array gain maximization’ block at the receiver sends *m* to the collocated ‘combiner block’. The ‘combiner block’ will combine the received signal, just as described in the previous sections, in order to deliver $\tilde{S}+\tilde{S}`$ to the ML detector. Note that $\tilde{S}$ is given in the previous sections and $\tilde{S}`$ is given by

$$\tilde{S}' = y' H^* \cdot w_m^T$$

with y’ being the signal received by the second RX antenna and **H** = [h_3 h_4], for 2TX, or **H** = [h_5 h_6 h_7 h_8], for 4 TX.

The technique described above is full rate and yields full spatial diversity added to antenna array gain thus yielding better link reliability.

13.2.3 Spatial multiplexing

13.2.3.1 Spatial multiplexing using 2 antennas

TBD

13.2.3.2 Spatial multiplexing using 4 antennas

TBD

13.2.4 Relaying

13.2.4.1 Relaying for 2 antennas

TBD

13.2.4.2 Relaying for 4 antennas

TBD