IEEE P802.16q AWD

~~**DRAFT Amendment to IEEE Standard for Local and metropolitan area networks**~~

Part 16: Air Interface for Broadband Wireless Access Systems

Amendment for Multi-tier Networks

~~Sponsor~~

~~**LAN/MAN Standards Committee of the IEEE Computer Society**~~

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Introduction

This introduction is not part of IEEE Std 802.16q, IEEE Standard for Interface for Broadband Wireless Access Systems - Amendment: Enhancements to Support Multi-tier Networks.

This amendment specifies support for Multi-tier Networks. As of the publication date, the current applicable version of IEEE Std 802.16 is IEEE Std 802.16-2012, as amended by IEEE 802.16n-2013.

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Air Interface for Broadband Wireless Access Systems —

Enhancements to Support Multi-tier Networks

NOTE-The editing instructions contained in this amendment define how to merge the material contained herein into the existing base standard IEEE Std 802.16. The editing instructions are shown in ***bold italic***. Four editing instructions are used: ***change***, ***delete***, ***insert***, and ***replace***. ***Change*** is used to make small corrections in existing text or tables. The editing instruction specifies the location of the change and describes what is being changed by using strike through (to remove old material) and underscore (to add new material). ***Delete*** removes existing material. ***Insert*** adds new material without disturbing the existing material. Insertions may require renumbering. If so, renumbering instructions are given in the editing instruction. ***Replace*** is used to make large changes in existing text, subclauses, tables, or figures by removing existing material and replacing it with new material. Editorial notes will not be carried over into future editions because the changes will be incorporated into the base standard.

1. Overview

Insert new subclause 1.9

1.9 Support for Multi-tier Networks

Multi-tier networks are an overlay deployments which consists of macro base stations and a variety of overlaid smaller base stations in order to further improve network capacity and efficiently manage radio resource. In multi-tier networks, coordination techniques between devices, between base stations across the multiple tiers, and between base stations in the same tier are important aspects of multi-tier network design to achieve system capacity enhancements and interference mitigation techniques across tiers are also critical to achieving the user throughput enhancements.

MAC/PHY protocol is enhanced throughout this standard to support efficient cooperation among base stations in multi-tier networks to enhance interference mitigation, mobility management, and base station power management. The management protocol between base stations and between base stations and mobile stations is improved to enable efficient cooperation and coordination. However, PHY layer of mobile stations has not been changed.

2. Normative references

3. Definitions

Insert the following definitions in alphabetical order:

BS power controller: BS power controller is a network element that performs BS power management services in the NCMS.

4. Abbreviations and acronyms

Insert the following abbreviations in alphabetical order:

CT cooperative transmission

IM interference management

6. MAC common part sublayer

6.3.2 MAC PDU formats

6.3.2.3 MAC management messages

Change the contents in Table 6-51 as indicated:

Table 6-51—MAC management messages

Type	Message name	Message description	Connection
144	IM_CT-REQ	IM Multi-BS CT Request	Basic
145	IM_CT-RSP	IM Multi-BS CT Response	Basic
~~110~~146-255		*Reserved*	

6.3.2.3.23 SBC-REQ (SS and RS basic capability request) message

Insert the following text at the end of 6.3.2.3.23:

The following parameter may be included if the MS supports the capability to support the Multi-BS CT.

Multi-BS CT support (11.8.25)

6.3.2.3.24 SBC-RSP (SS and RS basic capability response) message

Insert the following text at the end of 6.3.2.3.24:

The following parameter may be included in SBC-RSP.

Multi-BS CT support (11.8.25)

6.3.2.3.42 MOB_NBR-ADV (neighbor advertisement) message

Insert the following texts at the end of 6.3.2.3.43

The MOB_NBR-ADV message may include the following TLV.

Neighbor FA information

This TLV is used to provide the information required for the MS to scan neighbor small BSs deployed on a different frequency.

6.3.2.3.45 MOB_SCN-REP (scanning result report) message

Insert the following texts at the end of 6.3.2.3.45

The MOB_SCN-REP message may include the following TLV.

Neighbor request

This TLV is included in the MOB_SCN-REP to request a serving BS to unicast MOB_NBR-ADV message that contains system information of the neighbor BSs indicated by this TLV.

Insert the following new subclauses in 6.3.2.3

6.3.2.3.103 IM_CT-REQ (IM Multi-BS CT request) message

An MS capable of Multi-BS CT transmits to request neighbor BS(s) to add or delete to/from Multi-BS CT candidate set.

The format of the message is shown in Table 6-227am.

Table 6-227am—IM_CT-REQ message format

Syntax	Size (bit)	Notes
IM_CT-REQ_Message_Format() {	-	-
Management Message Type = 144	8	-
Action Type	8	Used to indicate the purpose of this message. Bit 0: Request to add the neighbor BS(s) to Multi-BS CT candidate set Bit 1: Request to delete the neighbor BS(s) from Multi-BS CT candidate set Bit 2: Request to update anchor BS Bit 3-7: *Reserved*
Report metric	8	Bitmap indicating presence of certain metrics (threshold values) on which the corresponding triggers are based: Bit 0: BS CINR mean Bit 1: BS RSSI mean Bit 2: Relative delay Bit 3-7: *Reserved*; shall be set to zero
if(Action Type[Bit 0] == 1) {	-	-
N_Neighbor_BS_Index	8	Number of neighbor BSs that are included in MOB_NBR-ADV message.
if(N_Neighbor_BS_Index != 0) {	-	-
Configuration change code for MOB_NBR-ADV	8	Configuration Change Count value of referring MONB_NBR-ADV message.
}	-	-
for(*i*=0;*i*<N_Neighbor_BS_Index;*i*++) {	-	-
Neighbor_BS_Index	8	BS index corresponds to position in MOB_NBR-ADV message.
if(Report metric[Bit 0] ==1)	-	-
BS CINR mean	8	-
if(Report metric[Bit 1] ==1)	-	-
BS RSSI mean	8	-

Table 6-227am—IM_CT-REQ message format

Syntax	Size (bit)	Notes
if(Report metric[Bit 2] ==1)	-	-
Relative delay	8	-
}	-	-
}	-	-
N_Neighbor_BS_Full	8	Number of neighbor BSs that are using full 48bits BSID.
for(*i*=0;*i*<N_Neighbor_BS_Full;*i*++) {	-	-
Neighbor BSID	48	-
if(Report metric[Bit 0] == 1)	-	-
BS CINR mean	8	-
if(Report metric[Bit 1] == 1)	-	-
BS RSSI mean	8	-
if(Report metric[Bit 2] == 1)	-	-
Relative delay	8	-
}	-	-
}		
N_Temp_BSID	4	Number of BSs in the Multi-BS CT candidate set.
Reserved	4	Shall be set to zero.
for(*i*=0;*i*<N_Temp_BSID;*i*++) {	-	-
Temp BSID	4	Member ID of the Multi-BS CT candidate set.
Reserved	4	Shall be set to zero.
if(Report metric[Bit 0] == 1)	-	-
BS CINR mean	8	-
if(Report metric[Bit 1] == 1)	-	-
BS RSSI mean	8	-
if(Report metric[Bit 2] == 1)	-	-
Relative delay	8	-
}	-	-
}	-	-
if(Action Type[Bit 1] == 1) {	-	-

Table 6-227am—IM_CT-REQ message format

Syntax	Size (bit)	Notes
N_Temp_BSID	4	Number of BSs in the Multi-BS CT candidate set.
Reserved	4	Shall be set to zero.
for(*i*=0;*i*<N_Temp_BSID;*i*++) {	-	-
Temp BSID	4	Member ID of the Multi-BS CT candidate set.
Reserved	4	Shall be set to zero.
if(Report metric[Bit 0] == 1)	-	-
BS CINR mean	8	-
if(Report metric[Bit 1] == 1)	-	-
BS RSSI mean	8	-
if(Report metric[Bit 2] == 1)	-	-
Relative delay	8	-
}	-	-
}	-	-
if(Action Type[Bit 2] == 1) {	-	-
Temp BSID	4	Member ID of the Multi-BS CT candidate set.
Reserved	4	Shall be set to zero.
}	-	-
}		

The following parameter shall be included if action type [Bit 0] or [Bit 1] is set to “1”.

Report metric

Bitmap indicator of trigger metrics that the serving BS requests the MS to report. The serving BS shall indicate only the trigger metrics agreed during SBC-REQ/RSP negotiation. For each bit location, a value of 0 indicates the trigger metric is not included, while a value of '1' indicates the trigger metric is included in the message. The bitmap interpretation for the metrics shall be as follows:

Bit 0: BS CINR mean

Bit 1: BS RSSI mean

Bit 2: Relative delay

Bits 3–7: *Reserved* ; shall be set to zero

N_Neighbor_BS_Index

Number of neighboring BS reported in this message and which are included in MOB_NBR-ADV message.

N_Neighbor_BS_Full

Number of neighboring BS reported in this message that are using full 48 bits BSID.

N_Temp_BSID

Number of BSs currently in the Multi-BS CT candidate set;

Configuration Change Count for MOB_NBR-ADV

The value of Configuration Change Count in MOB_NBR-ADV message referred in order to compress neighbor BSID.

Neighbor_BS_Index

BS index corresponds to position of BS in MOB_NBR-ADV message.

Neighbor BSID

Same as the Base Station ID parameter in the DL-MAP message of neighbor BS.

According to the report metric that MS indicates, the following parameter may be included if action type is set to 0b00 and 0b01:

BS CINR mean

The BS CINR Mean parameter indicates the CINR measured by the MS from the particular BS. The value shall be interpreted as a signed byte with units of 0.5 dB. The measurement shall be performed on the subcarriers of the frame preamble that are active in the particular BS's segment and averaged over the measurement period.

BS RSSI mean

The BS RSSI Mean parameter indicates the Received Signal Strength measured by the MS from the particular BS. The value shall be interpreted as an unsigned byte with units of 0.25 dB, e.g., 0x00 is interpreted as –103.75 dBm. An MS shall be able to report values in the range –103.75 dBm to –40 dBm. The measurement shall be performed on the frame preamble and averaged over the measurement period.

Relative delay

This parameter indicates the delay of neighbor DL signals relative to the serving BS, as measured by the MS for the particular BS. The value shall be interpreted as a signed integer in units of samples.

The following parameter shall be included if action type[Bit 0], [Bit 1], or [Bit 2] is set to "1":

Temp BSID

Member ID of Multi-BS candidate set assigned to this BS.

6.3.2.3.104 IMT_CT-RSP (IM Multi-BS CT response) message

In response to the IM_CT-REQ, a BS transmits to request neighbor BS(s) to update Multi-BS CT candidate set and anchor BS.

The format of the message is shown in Table 6-227an.

Table 6-227an—IM_CT-RSP message format

Syntax	Size (bit)	Notes
IM_CT-RSP_Message_Format() {	-	-
Management Message Type = 145	8	-
Action Type	8	Used to indicate the purpose of this message. Bit 0: Anchor BS update Bit 1: Multi-BS CT candidate set update Bit 2: CID update during anchor BS update or Multi-BS CT candidate set update Bit 3: Temp BS ID update Bit 4-7: *Reserved*
if(Action Type[Bit 0] == 1) {	-	-
TEMP_BSID_Anchor	4	Temp BSID for the new anchor BS
}	-	-
if(Action Type[Bit 1] == 1) {	-	-
N_New_Temp_BSID	4	Number of new BSs to add in the Multi-BS CT candidate set.
Reserved	4	Shall be set to zero.
for(*i*=0;*i*<N_New_Temp_BSID;*i*++) {		
Neighbor BSID	48	-
Temp BSID	4	Member ID of the Multi-BS CT candidate set.
Reserved	4	Shall be set to zero.
}	-	-
N_Temp_BSID	4	Number of BSs which are the member of new Multi-BS CT candidate set.
Reserved	4	Shall be set to zero.

Table 6-227an—IM_CT-RSP message format

Syntax	Size (bit)	Notes
for(*i*=0;*i*<N_Temp_BSID;*i*++) {	-	-
Temp BSID	4	Member ID of the Multi-BS candidate set.
Reserved	4	Shall be set to zero
}	-	-
}	-	-
if(Action Type[Bit 2] == 1) {	-	-
N_CID_Add	4	Number of CIDs to add.
N_CID_Update	4	Number of CIDs to update.
N_CID_Delete	4	Number of CIDs to delete.
Reserved	4	Shall be set to zero.
for(*i*=0;*i*<N_CID_Add;*i*++) {	-	-
New_CID_Add	16	New CID to use in the Multi-BS CT.
}	-	-
for(*i*=0;*i*<N_CID_Update;*i*++) {	-	-
Current_CID_Update	16	Current CID to delete in the Multi-BS CT.
New_CID_Update	16	New CID to add in the Multi-BS CT.
}	-	-
for(*i*=0;*i*<N_CID_Delete;*i*++) {	-	-
Current_CID_Delete	16	Current CID to delete from the Multi-BS CT.
}	-	-
}	-	-
if(Action Type[Bit 3] == 1) {	-	-
N_Temp_BSID_Update	4	Number of Temp BSID to update
for(*i*=0;*i*<N_Temp_BSID_Update;*i*++) {	-	-
Current_Temp_BSID_Update	16	Current Temp BSID to delete in the Multi-BS CT.
New_Temp_BSID_Update	16	New Temp BSID to add in the Multi-BS CT.
}	-	-
}	-	-

The following parameters shall be included if action type[Bit 0] is set to “1”.

TEMP_BSID_Anchor

New anchor BS Member ID of Multi-BS candidate set to update.

The following parameter shall be included if action type[Bit 1] is set to “1”:

N_New_Temp_BSID

Number of new BSs to add in the Multi-BS CT candidate set.

Neighbor BS ID

Same as the Base Station ID parameter in the DL-MAP message of neighbor BS.

Temp BS ID

Member ID of Multi-BS candidate set assigned to the BS.

The following parameter shall be included if action type[Bit 2] is set to “1”:

N_CID_Add

Number of CID to add.

N_CID_Update

Number of CID to update.

N_CID_Delete

Number of CID to delete.

New_CID_Add

New CID to use in the Multi-BS CT.

Current_CID_Update

Current CID to update in the Multi-BS CT.

Current_CID_Delete

Current CID to delete in the Multi-BS CT.

The following parameter shall be included if action type[Bit 3] is set to “1”:

N_Temp_BSID_Update

Number of Temp BSID to update.

Current_Temp_BSID_Update

Current Temp BSID to delete in the Multi-BS CT.

New_Temp_BSID_Update

New Temp BSID to add in the Multi-BS CT.

10. Parameters and constants

11. TLV encodings

11.3UCD management message encodings

11.3.1 UCD channel encodings

Insert the following parameter at the end of Table 11-15 as indicated:

Table 11-15—UCD PHY-specific channel encodings - WirelessMAN-OFDMA

Name	Type (1 byte)	Length	Value
Cell bar	225	1	0: this cell is allowed for network entry or reentry. 1: this cell is not allowed for network entry or reentry.

11.4.1 DCD management encodings

Insert the following rows at the end of Table 11-19

Table 11-19—DCD channel encodings

Name	Type (1byte)	Length	Value (variable length)	PHY scope
CT_Add Threshold	230	1	Threshold used by the MS to add a neighbor BS to the Multi-BS CT candidate set. When the CINR of a neighbor BS is higher than CT_Add, the MS should send IM_CT-REQ to request adding this neighbor BS to the Multi-BS CT candidate set. This threshold is used for Multi-BS CT operation. It is in the unit of decibels. If the BS does not support Multi-BS CT, this value is not set.	OFDMA
CT_Delete Threshold	231	1	Threshold used by the MS to drop a BS from the Multi-BS CT candidate set. When the CINR of a BS is lower than CT_Delete, the MS should send IM_CT-REQ to request dropping this BS from the Multi-BS CT candidate set. This threshold is used for Multi-BS CT operation. It is in the unit of decibels. If the BS does not support Multi-BS CT, this value is not set.	OFDMA

11.8 SBC-REQ/RSP management message encodings

Insert the following rosws at the end of table 11-35 in 11.8

Table 11-35—SBC-REQ/RSP management message encodings (OFDMA PHY-specific)

Type	Parameter	Type	Parameter
-	-	227	Multi-BS CT Support

Insert the following new subclause 11.8.25

11.8.25 Multi-BS CT support

The Multi-BS CT support field indicates the availability of MS support for Multi-BS CT operation. A bit value of 0 indicates “not supported” while 1 indicates “supported”.

Type	Length	Value	Scope
227	1	Bit 0: Multi-BS CT support Bit 1-7: Reserved; shall be set to zero	SBC-REQ (see 6.3.2.3.23) SBC-RSP (see 6.3.2.3.24)

11.18 MOB_NBR-ADV management message encodings

Insert the following new subclause 11.18.3

11.18.3 Neighbor FA information

Neighbor FA information TLV may be included in MOB_NBR-ADV message to provide the information required for an MS to scan neighbor small BSs deployed on a different frequency.

Name	Type	Length	Value
Neighbor FA information	23	variable	

Name	Type	Length	Value
FA index	23.1	1	Index of FA on which small BSs are deployed. The bit-by-bit definition shall be determined by a service provider or a governmental body like FCC.
Preamble index range	23.2	2	The preamble index range of neighbor BSs deployed on the same FA. Bits 0-7: preamble index range start Bits 8-15: preamble index range end

11.19 MOB_SCN-REP management message encodings

Insert the following new subclause 11.19.3

11.19.3 Neighbor request

Neighbor request TLV may be included in MOB_SCN-REP to request a serving BS to unicast MOB_NBR-ADV message that contains system information of the neighbor BSs detected during scanning. The neighbor request TLV may include request BS type and CSGID(s) and the serving BS may include a list of BSs that formed based on the reported BS type and CSGID(s).

Name	Type	Length	Value
Neighbor request	3	variable	

Name	Type	Length	Value
Request BS type	3.1	1	Type of neighbor small BSs for which system information is requested Bit 0: CSG-closed small BS Bit 1: CSG-open small BS Bit 2: OSG small BS Bit 3-7: Reserved
CSGID	3.2	TBD	Identifier of CSG to which the BS belongs

14. Management interface and procedures

This subclause defines the service primitives for use at C-SAP and M-SAP at BS and MS side of the radio interface. The specific mapping of service primitives to protocol messages in the backhaul network is out of scope of this standard.

Change subclause 14.1 as indicated:

14.1 Service primitive template

14.1.1 Universal naming schema for SAP service primitive

The primitive name defined on the SAP consists of three fields—SAP, Function, and Operation:

SAP

C – Control plane SAP

M – Management plane SAP

Function

ACM – Accounting Management

HO – Handover

IMM – Idle Mode Management

LBS – Location Based Services

MBS – Multicast Broadcast Service

NEM – Network Entry Management

RRM – Radio Resource Management

SFM – Service Flow Management

SM – Security Management

SMC – Secondary Management Connection

SSM – Subscriber Station Management

BPM – BS Power Management

IM – Interference Management

Operation

REQ – Request

RSP – Response to the REQ message

ACK – Acknowledgment to the reception of REQ or RSP or IND message

IND – Event Notification

These primitives are symmetrical between the IEEE 802.16 entity and the NCMS. That is, both the IEEE 802.16 entity (SS/MS or BS) and the NCMS can send these primitives depending on the functional behavior defined for M-SAP and C-SAP. ACK shall only be supported across the C-SAP.

—A service primitive of type REQ is used whenever a response to the primitive is solicited. If there is a REQ message on the radio interface, it is generally mapped to a REQ on C-SAP/M-SAP.

—A service primitive of type RSP is used in response to a REQ primitive. Moreover, if there is a RSP message on the radio interface, it is generally mapped to a RSP on C-SAP/M-SAP.

—A service primitive of type IND is used at C-SAP or M-SAP for event notification if a response to this primitive is not solicited, and if the primitive is not sent in response to a REQ primitive.

—A service primitive of type ACK can be used to acknowledge the receipt of a C-SAP primitive of type REQ, RSP, or IND.

The specific usage of these operation types for the respective control and management functions is specified in the subsequent subclauses.
The IEEE 802.16 entity shall support the primitives that are delivered through C-SAP or M-SAP interfacing with NCMS.

14.1.2 SAP service primitive object format

There are two types of services: M-SAP/C-SAP operation service primitive and M-SAP/C-SAP notification service primitive. The REQ and RSP operations shall use the operation service primitive and the IND operation shall use the notification service primitive. The ACK operation shall use the same primitive format as the primitive it acknowledges.

14.1.2.1 M-SAP/C-SAP operation service primitive

This primitive is defined as Primitive_name () with a parameter list.

The format shall be:

```
Primitive_name
(
        Operation_Type,
        Action_Type,
        Destination,
        Attribute_list
)
```

The parameters shall be described briefly in Table 14-1.

Table 14-1—M-SAP/C-SAP Operation Types

Parameter name	Mandatory/Optional	
Operation_Type	M	Create, Delete, Get, Set, Action
Action_Type	O	When Operation_Type is Action, valid values for Action_Type are: Certificate_Verification, Context_Transfer, Idle_Mode_Initiation, Network_Re-Entry_from_Idle_Mode, HO-Serving, HO-Target, HO-Mobile, Spare Capacity Report, PHY Report, Ranging, Registration, SS Basic Capability, Power On, Power Down, Reset, Hold, Normal, Deregistration, Location Update, Duty-cycled mode, Standby mode, IM_RM_Configuration, IM_CT_Configuration
Destination	M	This indicates the destination of the primitive. Allowed values are: SS or MS, BS, NCMS.
Attribute_list	O	~~Array of pair (Attribute_ID, Attribute_value). In Get request operation, Attribute_value is Null~~ If Operation_Type is set to Get for request operation, Attribute_list is array of only Attribute_ID. Otherwise if Attribute_list is present, Attribute_list is Array of the pair (Attribute_ID, Attribute_value)

14.1.2.2 M-SAP/C-SAP notification service primitive

This primitive shall be defined as Primitive_name () with a parameter list.
The format shall be:

```
Primitive_name
(
        Event_Type,
```

Destination,
Attribute_List
)

The parameters are described briefly in Table 14-2.

Table 14-2—M-SAP/C-SAP Event Types

Parameter name	Mandatory/ Optional	
Event_Type	M	Specify the type of occurring event, valid values for Event_Type are: Accounting, EAP_Start, EAP_Transfer, Certificate_Information, SMC_PAYLOAD, IP_ALLOCATION, Paging_Announce, HO-Start, HO-Cancel, HO-Scan, HO-CMPLT, MIH-IND, Spare Capacity Report, Neighbor-BS Radio Resource Stations Update, NBR_BS_Update, Network_attached, Location_Update_CMPLT, Reset, Hold, Normal, MBS Portion Layout, LBS, IM_RM_Report, IM_CT_Report, IM_CT_Indication
Destination	M	This indicates the destination of the primitive. Allowed values are: SS or MS, BS, NCMS..
Attribute_list	O	If Attribute_list is present, Attribute_list is Array of pair (Attribute_ID, Attribute_value)

14.1.3 SAP service primitive flow diagram template

Four typical handshake scenarios shown in Figure 14-1. The procedures are applicable to BS and SS side.

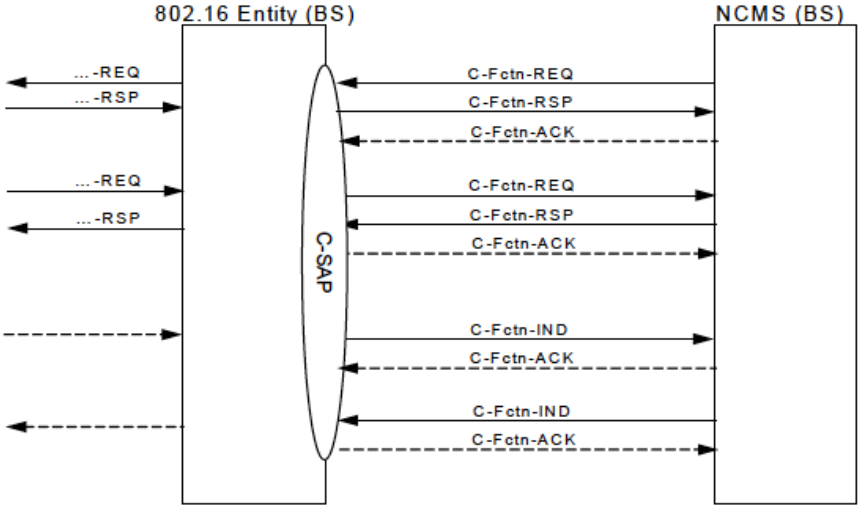

Figure 14-1—SAP service primitive Flow Diagram template

The figure is illustrative only and provides an example of correct formatting of primitive figures.

14.2 Management and control functions

Insert new subclause 14.2.12 as indicated:

14.2.12BS power management

The BS power management primitives are a set of primitives for supporting BS power management between IEEE 802.16 entity and NCMS. BS power management uses BS power management Services in the NCMS.

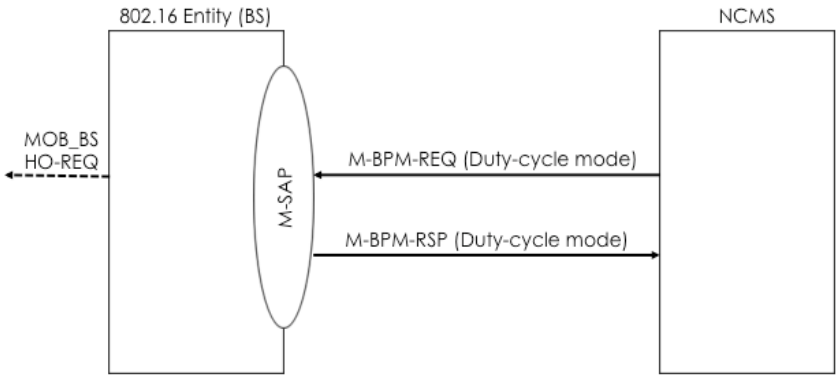

Figure 14-49—Primitive flow for duty-cycled mode transition

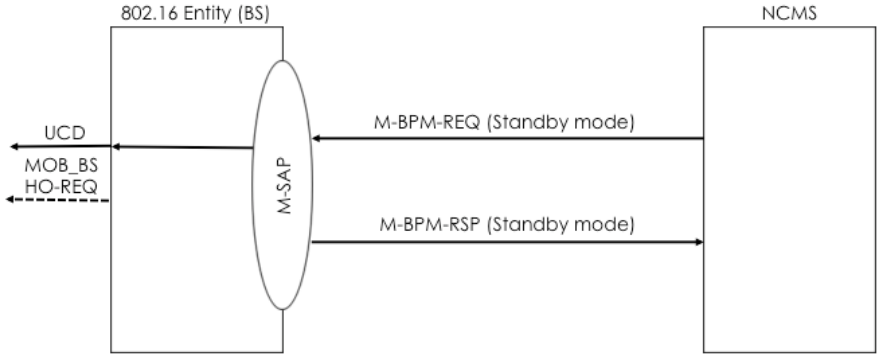

Figure 14-50—Primitive flow for NCMS-initiated standby mode transition

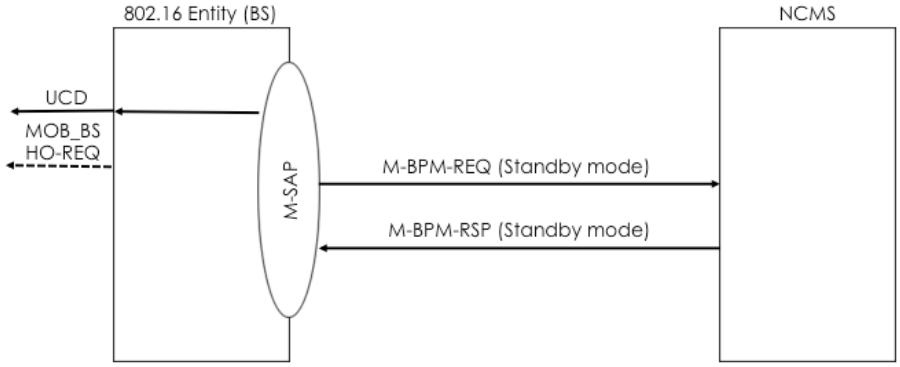

Figure 14-51—Primitive flow for BS-initiated standby mode transition

14.2.12.1 M-BPM-REQ

This primitive is used by a BS or an NCMS to control BS power management operation. The NCMS generates this primitive to request the IEEE 802.16 entity (BS) to perform operational mode transition and update of operation parameters for a specific operation mode. The possible Action_Types for this primitive are listed in table below:

Action_Type	Description
Duty-cycle mode	Duty-cycle mode transition procedure between BS and NCSM.
Standby mode	Standby mode transition procedure between BS and NCMS.

14.2.12.1.1 M-BPM-REQ (Action_Type = Duty-cycle mode)

14.2.12.1.1.1 Function

This primitive is used by the NCMS to control an operational mode of a BS and to update operational parameters for duty-cycle mode. This primitive is also used by the BS to report BS-initiated mode transition to the NCMS. The primitive is only used between IEEE 802.16 entity and NCMS at BS side.

14.2.12.1.1.2 Semantics

The following parameters are included in this primitive:

M-BPM-REQ
(
Operation_Type: Action,
Action_Type: Duty-cycle mode,
Destination: BS, NCMS,
Attribute_List:
Operation,
Duty-cycle pattern,
Reason
)

Operation
Indicates a type of operation
0: initiate duty-cycle mode
1: terminate duty-cycle mode
2: update of duty-cycle pattern

Duty-cycle pattern
Indicates a duty-cycle pattern that shall be used during duty-cycle mode. This parameter includes a length of an inactive interval, a length of an active interval and start frame offet. In case Operation is set to 2, the BS in duty-cycle mode shall update the current duty-cycle pattern with this duty-cycle pattern. This parameter is included in this primitive only when this parameter is generated by the NCMS.

Reason
Indicates a reason for mode transition. This parameter is included in this primitive only when this primitive is generated by the BS in duty-cycle mode to report the termination of duty-cycle mode (e.g., due to MS initial network entry or network reentry during an active interval)

14.2.12.1.1.3 When generated

- NCMS to BS: When a BS power controller in the NCMS makes a decision on mode transition of a BS for some reasons (e.g., interference mitigation, BS power saving, etc), the BS power controller in the NCMS generates this primitive to request the BS to initiate or terminate the duty-cycle mode. This primitive is also generated by the NCMS to request the BS in duty-cycle mode to update a duty-cycle pattern for an efficient operation of the duty-cycle mode.
- BS to NCMS: When a BS in duty-cycle mode has to terminate the duty-cycle mode for some reasons (e.g., a new initial network entry or network reentry), the BS generates this primitive to report the termination of the duty-cycle mode to the BS power controller in NCMS after transition to normal mode.

14.2.12.1.1.4 Effect of receipt

- NCMS to BS: If the BS receives this primitive, it shall perform the operation indicated by Operation parameter included in this primitive. If the Operation parameter is set to 0 (initiate duty-cycle mode), the BS first triggers its attached MSs, if any, to handover to the neighbor cells. After the completion of the operation requested by the NCMS, the BS shall generate M-BPM-RSP primitive to respond to this primitive.
- BS to NCMS: If the NCMS receives this primitive, it updates the current operational mode of the BS as normal mode and responds by generating M-BPM-RSP primitive.

14.2.12.1.2 M-BPM-REQ (Action_Type = Standby mode)

14.2.12.1.2.1 Function

This primitive is used by the NCMS to request initiation or termination of standby mode or to update mode transition time. This primitive is also used by the BS to report periodic mode transition to the NCMS. The primitive is only used between IEEE 802.16 entity and NCMS at BS side.

14.2.12.1.2.2 Semantics

The following parameters are included in this primitive :

M-BPM-REQ
(
Operation_Type: Action,
Action_Type: Standby mode,
Destination: BS, NCMS,
Attribute_List:
Operation,
Mode transition time
)

Operation
Indicates a type of operation
0: initiate standby mode
1: terminate standby mode
2: update of standby mode parameter
Mode transition time
Indicates when the BS initiates or terminates standby mode. If this parameter is not included in this primitive, the BS shall initiate or terminate the standby mode as soon as it receives this primitive. Otherwise, the BS initiates or terminates the standby mode at the time specified by this parameter.

14.2.12.1.2.3 When generated

- NCMS to BS: When a BS power controller in the NCMS makes a decision on mode transition of a BS for some reasons (e.g., interference mitigation, BS power saving, etc), the BS power controller in the NCMS generates this primitive to request the BS to initiate or terminate the standby mode. This primitive is also generated by the NCMS to specify when the BS performs standby mode initiation or termination.
- BS to NCMS: This primitive is generated by the BS after performing standby mode initiation or termination at the time that was previously specified by the NCMS.

14.2.12.1.2.4 Effect of receipt

- NCMS to BS: If the BS receives this primitive, it shall perform the operation indicated by Operation parameter included in this primitive. If the Operation parameter is set to 0 (initiate standby mode), the BS first triggers its attached MSs, if any, to handover to the neighbor cells. After the completion of the operation requested by the NCMS, the BS shall generate M-BPM-RSP primitive to respond to this primitive. If the Operation parameter is set to 1 (terminate standby mode), the BS shall transit to Initialization State after transmitting the M-BPM-RSP primitive. If the Operation parameter is set to 2 (update of standby mode parameter), the BS stays in the current operational mode and performs mode transition at the time specified by the Mode transition time parameter in this primitive.
- BS to NCMS: If the NCMS receives this primitive, it updates the current operational mode of the BS according to the Operation parameter in this primitive after generating M-BPM-RSP primitive.

14.2.12.2 M-BPM-RSP

This primitive is used by the BS or the NCMS in response to M-BPM-REQ primitive for BS power management. The possible Action_Types for this primitive are listed in table below:

Action_Type	Description
Duty-cycle mode	Duty-cycle mode transition procedure between BS and NCSM.
Standby mode	Standby mode transition procedure between BS and NCMS.

14.2.12.2.1 M-BPM-RSP (Action_Type = Duty-cycle mode)

14.2.12.2.1.1 Function

This primitive is used by the BS or the NCMS in response to M-BPM-REQ primitive for BS power management.

14.2.12.2.1.2 Semantics

The following parameters are included in this primitive:

M-BPM-RSP
(
Operation_Type: Action,
Action_Type: Duty-cycle mode,
Destination: NCMS, BS
Attribute_List:
Operation,
Result,
Reason
)

Operation

Indicates a type of operation. The value of this parameter shall be the same as one included in the received M-BPM-REQ primitive.

0: initiate duty-cycle mode
1: terminate duty-cycle mode
2: update of duty-cycle pattern

Result

Indicates a result of the operation indicated by the Operation parameter included in the received M-BPM-REQ primitive. This parameter may include ‘success’ or ‘failure’.

Reason

Indicates a reason for failure. This parameter is included in this primitive only when the Result parameter in this primitive is set to ‘failure’.

14.2.12.2.1.3 When generated

- BS to NCMS: If the BS receives the M-BPM-REQ primitive, it generates this primitive after performing the operation indicated by Operation parameter included in the M-BPM-REQ primitive.
- NCMS to BS: If the NCMS receives the M-BPM-REQ primitive, it updates the current operational mode of the BS as normal mode and responds by generating this primitive.

14.2.12.2.1.4 Effect of receipt

- BS to NCMS: If the Result parameter is set to ‘success’, the NCMS updates a current operational mode of the BS. The NCMS may notify neighbor BSs of information on the BS’s operational mode and relevant parameters. This information may be used by the neighbor BSs for radio resource management. If the Result parameter is set to ‘failure’, the NCMS may re-generate M-BPM-REQ primitive or terminate the transaction according to service provider’s policy. If the NCMS does not receive this primitive within a pre-defined time, the NCMS regards this transaction as failure.
- NCMS to BS: If the BS receives this primitive, it terminates this transaction.

14.2.12.2.2 M-BPM-RSP (Action_Type = Standby mode)

14.2.12.2.2.1 Function

This primitive is used by the BS or the NCMS in response to M-BPM-REQ primitive for BS power management.

14.2.12.2.2.2 Semantics

The following parameters are included in this primitive:

M-BPM-RSP
(
Operation_Type: Action,
Action_Type: Standby mode,
Destination: BS, NCMS
Attribute_List:
Operation,
Result,
Reason
)

Operation

Indicates a type of operation.

0: initiate standby mode
1: terminate standby mode
2: update of standby mode parameter

Result
Indicates a result of the operation indicated by the Operation parameter included in the received M-BPM-REQ primitive. This parameter may include ‘success’ or ‘failure’.

Reason
Indicates a reason for failure. This parameter is included in this primitive only when the Result parameter in this primitive is set to ‘failure’.

14.2.12.2.2.3 When generated

- BS to NCMS: If the BS receives the M-BPM-REQ primitive, it generates this primitive after performing the operation indicated by Operation parameter included in the M-BPM-REQ primitive.
- NCMS to BS: If the NCMS receives the M-BPM-REQ primitive, the NCMS updates the current operational mode of the BS according to the Operation parameter in the received M-BPM-REQ primitive after generating this primitive.

14.2.12.2.2.4 Effect of receipt

- BS to NCMS: If the Result parameter is set to ‘success’, the NCMS updates a current operational mode of the BS. The NCMS may notify neighbor BSs of the BS’s operational mode for them to manage neighbor BS list. If the Result parameter is set to ‘failure’, the NCMS may re-generate M-BPM-REQ primitive or terminate the transaction according to service provider’s policy. If the NCMS does not receive this primitive within a pre-defined time, the NCMS regards this transaction as failure
- NCMS to BS: If the BS receives this primitive, it terminates this transaction.

Insert new subclause 14.2.13 as follows:

14.2.13 Interference management

The IM Primitives are a set of primitives for supporting IM procedure between IEEE 802.16 entity and NCMS, as well as between IEEE 802.16 entities. The IM Primitives include resource management for IM and cooperative transmission primitives.

Figure 14-52 to 54 shows the IM Control Primitives.

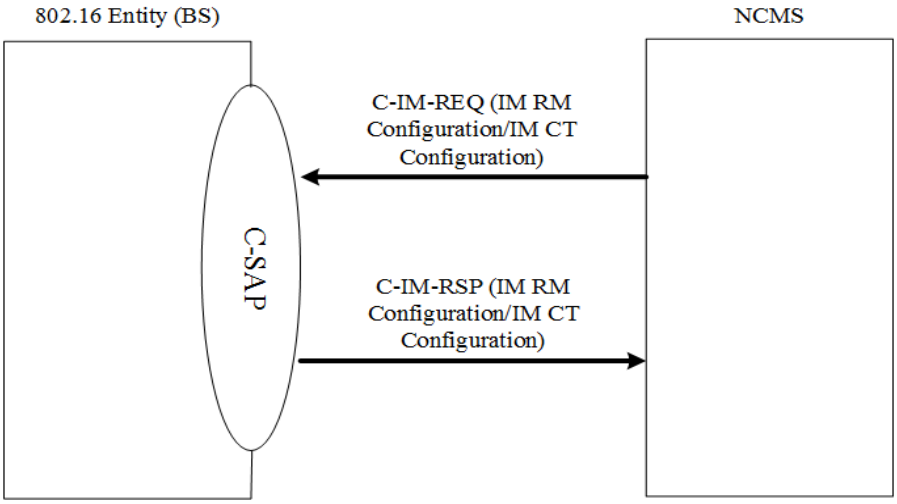

Figure 14-52—Primitive flow of C-IM--REQ/RSP

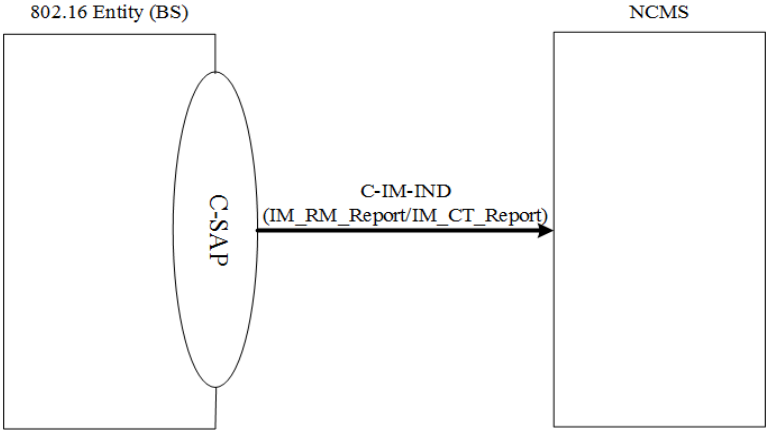

Figure 14-53—Primitive flow between IEEE 802.16 entity (BS) and NCMS (IM_RM_Report/IM_CT_Report)

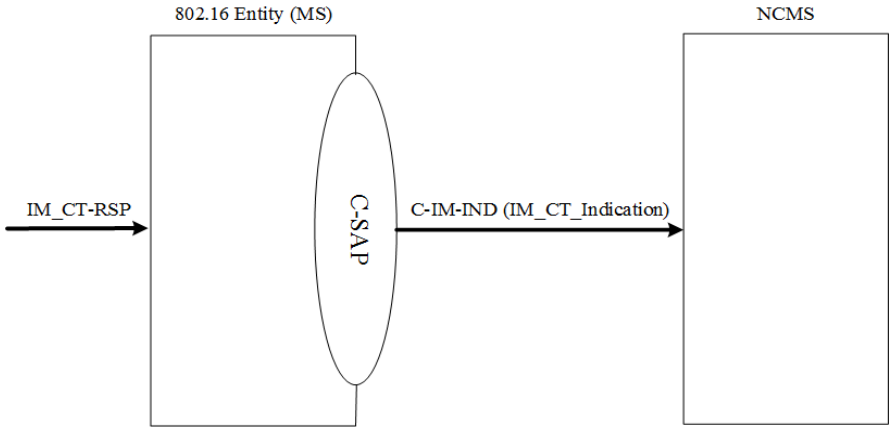

Figure 14-54—Primitive flow between IEEE 802.16 entity (BS) and NCMS when C-IM-RSP message is received

14.2.13.1 C-IM-REQ

This primitive is used by NCMS to request the IEEE 802.16 entity to perform interference management procedures. The Action_Types for this primitive are listed in the following table.

Action_Type	Description
IM RM Configuration	Configuration procedure between BS and NCMS on resource management for IM.
IM CT Configuration	Configuration procedure between BS and NCMS on Multi-BS CT for IM.

14.2.13.1.1 C-IM-REQ (Action_Type = IM_RM_Configuration)

14.2.13.1.1.1 Function

This primitive is used by the NCMS to request a BS to provide information.

14.2.13.1.1.2 Semantics

C-IM-REQ
(
Operation_Type: Action,
Action_Type: IM_RM_Configure,
Destination: BS,
Attribute_List:

```
                Request Type,
                List of Configuration Attributes:
                (
                        N_PERMUTATION_ZONES,
                        for(i=0, i<N_PERMUTATION_ZONES; i++)
                        (
                                Permutation scheme,
                                Permutation Zone Subchannel Bitmap,
                                Use All SC,
                                DL_PermBase,
                                PRBS_ID,
                                AMC type,
                                OFDMA Symbol Offset,
                                Number of OFDMA Symbols,
                                Subchannel offset,
                                Number of Subchannels,
                                Tx Power
                        )
                )
                Action Time,
                List of Report Attributes:
                (
                        Report type,
                        Report Period P,
                        Report Threshold RT,
                        MS MAC Address
                )
)
```

Request Type

Type of request; bitmap:

Bit 0: Set the partition

Bit 1: Report status

When Request Type is set to “Set the partition”, following attribute lists are valid:

N_PERMUTATION_ZONES

Number of radio frame subsections for which the resource partition will be indicated. A value of 1 indicates that the entire DL and UL radio subframe is considered to be a single permutation zone each.

Permutation scheme

Denotes permutation scheme used in the current permutation zone. The following types are possible:

- DL PUSC permutation
- DL FUSC permutation
- DL Optional FUSC permutation
- DL AMC
- DL TUSC1
- DL TUSC2
- UL PUSC
- UL AMC

Permutation Zone Subchannel Bitmap

Indicates the subchannels available for transmission in the current permutation zone

Use All SC

When set, this field indicates transmission on all available subchannels. For FUSC permutation, transmission is always on all subchannels.

DL_PermBase

DL Permutation base for the specified DL zone. DL_PermBase field shall be set to the 5 LSBs of IDcell as indicated by the frame preamble.

PRBS_ID

Values: 0..2. Refer to 8.4.9.4.1.

AMC type

Indicates the AMC type in case permutation type = 0b11, otherwise shall be set to 0.
AMC type (NxM = N bins by M symbols):
- 1x6
- 2x3
- 3x2

Note that only 2x3 band AMC subchannel type (AMC Type = 0b01) is supported by MS

OFDMA Symbol offset

Denotes the start of the current permutation zone in number of OFDMA symbols (counting from the frame preamble and starting from 0)

Number of OFDMA Symbols

Denotes the number of OFDMA symbols used in the current permutation zone.

Subchannel offset

Denotes the start of the current zone in number of OFDMA subchannels

Number of Subchannels

Denotes the number of OFDMA subchannels used in the current permutation zone.

Tx Power

Denotes the maximum transmit power used in the current permutation zone (in dBm).

Action Time

Denotes the time to start this action.

When Request Type is set to “Report status”, following attribute lists are valid:

Report type

Indicates the type to report the status:
- radio resource status
- report the link level quality for a specific MS

Report Characteristics

Indicates whether the report shall be sent periodically, or event driven.
- Bit 0: Periodically as defined by report period P.
- Bit 1: regularly whenever resource have changed as defined by RT since the last report.

Bit 2: Change of IM RM configuration (set the partition). This report shall be given whenever any of the parameters (Request type [bit 0] is set to “set the partition”) at the BS have changed.

Bit 3: Report shall be given per permutation zone.

Report Period P

The Time P is used by the BS as reporting period for producing the information requested by the NCMS.

Report Threshold RT

The threshold value RT shall be used by the BS to send another report as soon as value to report increases by more than that threshold value.

MS MAC Address

48-bit unique identifier of the MS. Only valid when the report type is for “report the link level quality for a specific MS”

14.2.13.1.1.3 When generated

The NCMS at BS side may use this primitive at any time to order a BS to perform resource management operation for IM for subordinate MS(s).

14.2.13.1.1.4 Effect of receipt

The BS shall generate the required operation related to configure resource management, e.g., resource partitioning, report based on the report type for IM.

14.2.13.1.2 C-IM-REQ (Action_Type = IM_CT_Configuration)

14.2.13.1.2.1 Function

This primitive is used by the NCMS to request a BS to provide information.

14.2.13.1.2.2 Semantics

C-IM-REQ
(
Operation_Type: Action,
Action_Type: IM_CT_Configure,
Destination: BS,
Attribute_List:
Request Type,
N_PERMUTATION_ZONES
List of Configuration Attributes:
(
N_PERMUTATION_ZONES,
for(i=0, i<N_PERMUTATION_ZONES; i++)
(
Permutation scheme,
Permutation Zone Subchannel Bitmap,
Use All SC,
DL_PermBase,
PRBS_ID,
AMC type,
OFDMA Symbol Offset,
Number of OFDMA Symbols,
Subchannel offset,
Number of Subchannels,
Tx Power,
STC,
Midamble presence,
Midamble boosting,
Dedicated Pilots,
N_CT,
for(j=0, j<N_CT; j++)
(
Multi-BS CT_ID,
Anchor Temp BSID,
Temp BSID,
N_BS_SETS,
for all BSs in the BS_SET List:

Neighbor BSID,
Neighbor Temp BSID,
List of Antenna configuration Attributes:
(
Matrix indicator
For all antennas of BS:
Antenna index of BS,
Antenna index for Multi-BS CT
)
)
)
)
CT Add Threshold,
CT Delete Threshold,
Action Time,
Report type,
REport Characteristics,
Report Period P,
Report Threshold RT,
MS MAC Address,
N_BS_SETS,
for all BSs in the BS_SET List:
BSID,
Temp BSID
)

Request Type

Type of request; bitmap:
Bit 0: Set the Multi-BS CT
Bit 1: Report status

When Request Type is set to "Set the Multi-BS CT", following attribute lists are valid:

N_PERMUTATION_ZONES

Number of radio frame subsections for which the resource partition will be indicated. A value of 1 indicates that the entire DL and UL radio subframe is considered to be a single permutation zone each.

Permutation scheme

Denotes permutation scheme used in the current permutation zone. The following types are possible:
- DL PUSC permutation
- DL FUSC permutation
- DL Optional FUSC permutation
- DL AMC
- DL TUSC1
- DL TUSC2
- UL PUSC
- UL AMC

Permutation Zone Subchannel Bitmap

Indicates the subchannels available for transmission in the current permutation zone

Use All SC

When set, this field indicates transmission on all available subchannels. For FUSC permutation, transmission is always on all subchannels.

DL_PermBase

DL Permutation base for the specified DL zone. DL_PermBase field shall be set to the 5 LSBs of IDcell as indicated by the frame preamble.

PRBS_ID

Values: 0..2. Refer to 8.4.9.4.1.

AMC type

Indicates the AMC type in case permutation type = 0b11, otherwise shall be set to 0.
AMC type (NxM = N bins by M symbols):
- 1x6
- 2x3
- 3x2

Note that only 2x3 band AMC subchannel type (AMC Type = 0b01) is supported by MS

OFDMA Symbol offset

Denotes the start of the current permutation zone in number of OFDMA symbols (counting from the frame preamble and starting from 0)

Number of OFDMA Symbols

Denotes the number of OFDMA symbols used in the current permutation zone.

Subchannel offset

Denotes the start of the current zone in number of OFDMA subchannels

Number of Subchannels

Denotes the number of OFDMA subchannels used in the current permutation zone.

Tx Power

Denotes the maximum transmit power used in the current permutation zone (in dBm).

STC

Denotes the STC in the current permutation zone:
- No STC
- STC using 2 antennas
- STC using 3 antennas
- STC using 4 antennas
- FHDC using 2 antennas

Midamble presence

Indicates midamble presence in the first symbol of the current permutation zone with the corresponding antenna configuration, as specified in 8.4.8.5.

Midamble boosting

Indicates whether the midamble is boosting when midamble presence is set.

Dedicated Pilots

Indicates whether the pilot symbols are broadcast or dedicated:
- broadcast

dedicate

N_CT

Indicates the number of Multi-BS CT supported in the current permutation.

Multi-BS CT_ID

Indicates identifier of the Multi-BS CT.

Anchor Temp BSID

Indicates the Temp BSID (member ID) of the anchor BS in the Multi-BS CT group (identified by Multi-BS CT ID)

Temp BSID

Indicates the Temp BSID(member ID) of the BS in the Multi-BS CT group (identified by Multi-BS CT ID)

N_BS_SETS

Number of neighbor BSs in the current Multi-BS CT group (identified by Multi-BS CT ID).

Neighbor BSID

ID of the neighbor BS

Neighbor Temp BSID

Temp BSID of the neighbor BS in the Multi-BS CT group (identified by Multi-BS CT ID)

Matrix indicator

Indicates the STC matrix to be used in the Multi-BS CT.

- Matrix A
- Matrix B
- Matrix C

Antenna index of BS

Indicates the antenna index of the BS

Antenna index for Multi-BS CT

Indicates the antenna index to be used in the Multi-BS CT.

CT Add Threshold

Number of neighbor BSs in the current Multi-BS CT group (identified by Multi-BS CT ID).

CT Delete Threshold

Indicates the threshold values to delete the neighbor BS from the multi-BS candidate set.

Action Time

Denotes the time to start this action.

When Request Type is set to "Report status", following attribute lists are valid:

Report type

Indicates the type to report the status:

- report the link level quality for a specific MS

Report Characteristics

Indicates whether the report shall be sent periodically, or event driven.

- Bit 0: Periodically as defined by report period P.
- Bit 1: regularly whenever resource have changed as defined by RT since the last report.
- Bit 2: Change of IM RM configuration (set the partition). This report shall be given whenever any of the parameters (Request type [bit 0] is set to "set the Multi-BS CT") at the BS have changed.
- Bit 3: Report shall be given per permutation zone.

Report Period P

The Time P is used by the BS as reporting period for producing the information requested by the NCMS.

Report Threshold RT

The threshold value RT shall be used by the BS to send another report as soon as value to report increases by more than that threshold value.

MS MAC Address

48-bit unique identifier of the MS. Only valid when the report type is for "report the link level quality for a specific MS"

14.2.13.1.2.3 When generated

The NCMS at BS side may use this primitive at any time to order a BS to perform multi-BS CT operation for IM for subordinate MS(s).

14.2.13.1.2.4 Effect of receipt

The BS shall generate the required operation related to configure multi-BS CT operation, e.g., Multi-BS CT operational mode set/update, Multi-BS CT set update, anchor BS update, Temp BSID update for IM.

14.2.13.2 C-IM-RSP

This primitive is used by the IEEE 802.16 entity in response to the C-IM-REQ primitive. The Action_Types for this primitive are listed in the following table.

Action_Type	Description
IM RM Configuration	Configuration procedure between BS and NCMS on resource management for IM.
IM CT Configuration	Configuration procedure between BS and NCMS on Multi-BS CT for IM.

14.2.13.2.1 C-IM-RSP (Action_Type = IM_RM_Configuration)

14.2.13.2.1.1 Function

This primitive is generated by the BS to provide information to the NCMS in response to C-IM-REQ message from the NCMS.

14.2.13.2.1.2 Semantics

C-IM-RSP
(
Operation_Type: Action,
Action_Type: IM_CT_Configure,
Destination: NCMS,
Attribute_List:
Response Type,
N_PERMUTATION_ZONES,
List of Configuration Attributes:
(
N_PERMUTATION_ZONES,
for(i=0, i<N_PERMUTATION_ZONES; i++)
(
Permutation scheme,
Permutation Zone Subchannel Bitmap,
Use All SC,
DL_PermBase,
PRBS_ID,
AMC type,
OFDMA Symbol Offset,
Number of OFDMA Symbols,
Subchannel offset,
Number of Subchannels,
Tx Power,
List of Resource Usage Report Attributes:
(
Available Radio Resource,

Radio Resource Fluctuation
)
)
)
List of PHY Report Attributes:
(
MS MAC Address,
Downlink Physical Service Level,
Downlink RSSI mean,
Downlink RSSI standard deviation,
Downlink CINR mean,
Downlink CINR standard deviation,
Uplink Physical Service Level,
Uplink RSSI mean,
Uplink RSSI standard deviation,
Uplink CINR mean,
Uplink CINR standard deviation
)
)

Response Type

Type of report profiles:

Partitioning configuration complete
Resource Usage Report
PHY Report

When Response Type is set to “Partitioning configuration complete” or “Resource Usage Report”, following attribute lists are valid:

N_PERMUTATION_ZONES

Number of radio frame subsections for which the resource partition will be indicated. A value of 1 indicates that the entire DL and UL radio subframe is considered to be a single permutation zone each.

Permutation scheme

Denotes permutation scheme used in the current permutation zone. The following types are possible:

- DL PUSC permutation
- DL FUSC permutation
- DL Optional FUSC permutation
- DL AMC
- DL TUSC1
- DL TUSC2
- UL PUSC
- UL AMC

OFDMA Symbol offset

Denotes the start of the current permutation zone in number of OFDMA symbols (counting from the frame preamble and starting from 0)

When Response Type is set to “Partitioning configuration complete”, following attribute lists are valid:

Permutation Zone Subchannel Bitmap

Indicates the subchannels available for transmission in the current permutation zone

Use All SC

When set, this field indicates transmission on all available subchannels. For FUSC permutation, transmission is always on all subchannels.

DL_PermBase

DL Permutation base for the specified DL zone. DL_PermBase field shall be set to the 5 LSBs of IDcell as indicated by the frame preamble.

PRBS_ID

Values: 0..2. Refer to 8.4.9.4.1.

AMC type

Indicates the AMC type in case permutation type = 0b11, otherwise shall be set to 0.
AMC type (NxM = N bins by M symbols):
- 1x6
- 2x3
- 3x2

Note that only 2x3 band AMC subchannel type (AMC Type = 0b01) is supported by MS

Number of OFDMA Symbols

Denotes the number of OFDMA symbols used in the current permutation zone.

Subchannel offset

Denotes the start of the current zone in number of OFDMA subchannels

Number of Subchannels

Denotes the number of OFDMA subchannels used in the current permutation zone.

Tx Power

Denotes the maximum transmit power used in the current permutation zone (in dBm).

When Response Type is set to “Resource Usage Report”, following attribute lists are valid:

Available RAdio Resource

Percentage of reported average available subchannels and symbols resources (“slots”) per frame. If N_PERMUTATION_ZONES > 1, the indicator covers a permutation zone instead of the entire DL or UL radio subframe.

Radio Resource Fluctuation

Radio Resource Fluctuation is used to indicate the degree of fluctuation in DL and UL channel data traffic throughputs. If N_PERMUTATION_ZONES > 1, the indicator covers a permutation zone instead of the radio frame. When Radio Resource Fluctuation is set to 0, it implies that the DL and UL data traffic is constant in data throughput. Hence, there is no fluctuation in Available Radio Resource. When Radio Resource Fluctuation is set to maximum value 255, the data traffic is very volatile in nature, which makes the Available Radio Resource unpredictable. The Radio Resource Fluctuation for all traffic models should be in the range of 0 to 255.

When Indication Type is set to “PHY report”, following attribute lists are valid:

MS MAC Address

48-bit unique identifier of the MS. Only valid when the report type is for “report the link level quality for a specific MS”

Downlink Physical Service Level

Channel rate available for the MS calculated as a multiple of 1/32 of nominal bandwidth in the correspondent direction assuming 1 bit/Hz. For example, if DL channel bandwidth is 10 MHz, value PSL=4 means 4 × 1/32 ×10 Mbps = 1.25 Mbps. 1 PSL 96 (Number of subchannels in different OFDMA modes is multiple of 16 or 32; highest modulation (QAM64) provides 3 bits/Hz)

Downlink RSSI mean

As specified in 8.1.9.

Downlink RSSI standard deviation

As specified in 8.1.9.

Downlink CINR mean

As specified in 8.1.9.

Downlink CINR standard deviation
As specified in 8.1.9.
Uplink Physical Service Level
Channel rate available for the MS calculated as a multiple of 1/32 of nominal bandwidth in the correspondent direction assuming 1 bit/Hz. (see definition of Downlink Physical Service Level)
Uplink RSSI mean
As specified in 8.1.9.
Uplink RSSI standard deviation
As specified in 8.1.9.
Uplink CINRmean
As specified in 8.1.9.
Uplink CINR standard deviation
As specified in 8.1.9.

14.2.13.2.1.3 When generated

This primitive is generated by the BS to notify the NCMS of C-IM-REQ contents received from the NCMS.

14.2.13.2.1.4 Effect of receipt

The NCMS may use the received C-IM-RSP contents for any purpose, e.g., resource partitioning for IM.

14.2.13.2.2 C-IM-RSP (Action_Type = IM_CT_Configuration)

14.2.13.2.2.1 Function

This primitive is generated by the BS to provide information to the NCMS in response to C-IM-REQ message from the NCMS.

14.2.13.2.2.2 Semantics

C-IM-RSP
(
Operation_Type: Action,
Action_Type: IM_CT_Configure,
Destination: NCMS,
Attribute_List:
Response Type,
Update Type,
Multi-BS CT_ID,
Anchor Temp BSID,
N_Temp_ID,
for all BSs in the Multi-BS CT set:
Temp BSID,
N_CID
for all connection in the Multi-BS CT set:
CID
list of PHY Report Attributes:
(
MS MAC Address,
Temp BSID for PHY report,

Downlink Physical Service Level,
Downlink RSSI mean,
Downlink RSSI standard deviation,
Downlink CINR mean,
Downlink CINR standard deviation,
Uplink Physical Service Level,
Uplink RSSI mean,
Uplink RSSI standard deviation,
Uplink CINR mean,
Uplink CINR standard deviation
)
)

Response Type
Type of report profiles:
Multi-BS CT configuration complete
PHY Report

When Request Type is set to "Multi-BS CT configuration complete", following attribute lists are valid:

Update Type
Type of update; bitmap:
- Bit 0: Anchor BS update
- Bit 1: Multi-BS CT candidate set update
- Bit 2: CID update during anchor BS update or Multi-BS CT candidate set update
- Bit 3: Temp BSID update

Multi-BS CT_ID
Indicates identifier of the Multi-BS CT.

Anchor Temp BSID
Temp BSID of the anchor BS, which is the member ID of the Multi-BS CT set.

N_Temp_ID
The counter of the Temp BSID.

Temp BSID
Member identifier of the Multi-BS CT candidate set.

N_CID
The counter of the CID.

CID
Connection identifier

When Response Type is set to "PHY Report", following attribute lists are valid:

MS MAC Address
48-bit unique identifier of the MS.

Temp BSID for PHU report
Member identifier of the Multi-BS CT set for PHY report

Downlink Physical Service Level
Channel rate available for the MS calculated as a multiple of 1/32 of nominal bandwidth in the correspondent direction assuming 1 bit/Hz. For example, if DL channel bandwidth is 10 MHz, value PSL=4 means 4 × 1/32 ×10 Mbps = 1.25 Mbps. 1 PSL 96 (Number of subchannels in different OFDMA modes is multiple of 16 or 32; highest modulation (QAM64) provides 3 bits/Hz)

Downlink RSSI mean
As specified in 8.1.9.

Downlink RSSI standard deviation
As specified in 8.1.9.

Downlink CINR mean
As specified in 8.1.9.
Downlink CINR standard deviation
As specified in 8.1.9.
Uplink Physical Service Level
Channel rate available for the MS calculated as a multiple of 1/32 of nominal bandwidth in the correspondent direction assuming 1 bit/Hz. (see definition of Downlink Physical Service Level)
Uplink RSSI mean
As specified in 8.1.9.
Uplink RSSI standard deviation
As specified in 8.1.9.
Uplink CINRmean
As specified in 8.1.9.
Uplink CINR standard deviation
As specified in 8.1.9.

14.2.13.2.2.3 When generated

This primitive is generated by the BS to notify the NCMS of C-IM-REQ contents received from the NCMS.

14.2.13.2.2.4 Effect of receipt

The NCMS may use the received C-IM-RSP contents for any purpose, e.g., Multi-BS CT decision, mode selection, and anchor BS update for IM.

14.2.13.3 C-IM-IND

This primitive is used by the IEEE 802.16 entity to notify the NCMS complete the configuration related to operation for IM and the periodic/event-triggered report, which is not the immediate response to a C-IM-REQ received from the NCMS. The Action_Types for this primitives are listed in in the following table:

Event_Type	Description
IM RM Report	Indicating the report related to resource management for IM
IM CT Report	Indicating the report related to Multi-BS CT for IM
IM CT Indication	Indicating the complete of operation related to Multi-BS CT for IM.

14.2.13.3.1 C-IM-IND (Event_Type = IM_RM_Report)

14.2.13.3.1.1 Function

This primitive is generated by the BS to notify the NCMS about the report related to resource management for IM, which is not the immediate response to a C-IM-REQ received from the NCMS.

14.2.13.3.1.2 Semantics

C-IM-IND

```
(
        Event_Type: IM_RM_Report,
        Destination: NCMS,
        Attribute_List:
                Indication Type,
                N_PERMUTATION_ZONES
                List of Configuration Attributes:
                (
                        N_PERMUTATION_ZONES,
                        for(i=0, i<N_PERMUTATION_ZONES; i++)
                        (
                                Permutation scheme,
                                Permutation Zone Subchannel Bitmap,
                                Use All SC,
                                DL_PermBase,
                                PRBS_ID,
                                AMC type,
                                OFDMA Symbol Offset,
                                Number of OFDMA Symbols,
                                Subchannel offset,
                                Number of Subchannels,
                                Tx Power,
                                List of Resource Usage Report Attributes:
                                (
                                        Available Radio Resource,
                                        Radio Resource Fluctuation
                                )
                        )
                )
                List of PHY Report Attributes:
                (
                        MS MAC Address,
                        Downlink Physical Service Level,
                        Downlink RSSI mean,
                        Downlink RSSI standard deviation,
                        Downlink CINR mean,
                        Downlink CINR standard deviation,
                        Uplink Physical Service Level,
                        Uplink RSSI mean,
                        Uplink RSSI standard deviation,
                        Uplink CINR mean,
                        Uplink CINR standard deviation
                )
)
```

Indication Type

Type of report profiles:

Resource Usage Report

PHY Report

When Indication Type is set to “Partitioning configuration complete”, following attribute lists are valid:

N_PERMUTATION_ZONES

Number of radio frame subsections for which the resource partition will be indicated. A value of 1 indicates that the entire DL and UL radio subframe is considered to be a single permutation zone each.

Permutation scheme

Denotes permutation scheme used in the current permutation zone. The following types are possible:

- DL PUSC permutation
- DL FUSC permutation
- DL Optional FUSC permutation
- DL AMC
- DL TUSC1
- DL TUSC2
- UL PUSC
- UL AMC

OFDMA Symbol offset

Denotes the start of the current permutation zone in number of OFDMA symbols (counting from the frame preamble and starting from 0)

When Indication Type is set to "Partitioning configuration complete", following attribute lists are valid:

Permutation Zone Subchannel Bitmap

Indicates the subchannels available for transmission in the current permutation zone

Use All SC

When set, this field indicates transmission on all available subchannels. For FUSC permutation, transmission is always on all subchannels.

DL_PermBase

DL Permutation base for the specified DL zone. DL_PermBase field shall be set to the 5 LSBs of IDcell as indicated by the frame preamble.

PRBS_ID

Values: 0..2. Refer to 8.4.9.4.1.

AMC type

Indicates the AMC type in case permutation type = 0b11, otherwise shall be set to 0.
AMC type (NxM = N bins by M symbols):

- 1x6
- 2x3
- 3x2

Note that only 2x3 band AMC subchannel type (AMC Type = 0b01) is supported by MS

Number of OFDMA Symbols

Denotes the number of OFDMA symbols used in the current permutation zone.

Subchannel offset

Denotes the start of the current zone in number of OFDMA subchannels

Number of Subchannels

Denotes the number of OFDMA subchannels used in the current permutation zone.

Tx Power

Denotes the maximum transmit power used in the current permutation zone (in dBm).

When Indication Type is set to "Resource Usage report", following attribute lists are valid:

Available RAdio Resource

Percentage of reported average available subchannels and symbols resources ("slots") per frame. If N_PERMUTATION_ZONES > 1, the indicator covers a permutation zone instead of the entire DL or UL radio subframe.

Radio Resource Fluctuation

Radio Resource Fluctuation is used to indicate the degree of fluctuation in DL and UL channel data traffic throughputs. If N_PERMUTATION_ZONES > 1, the indicator covers a permutation zone instead of the radio frame. When Radio Resource Fluctuation is set to 0, it implies that the DL and UL data traffic is constant in data throughput. Hence, there is no fluctuation in Available Radio Resource. When Radio Resource Fluctuation is set to maximum value 255, the data traffic is very volatile in nature, which makes the Available Radio Resource unpredictable. The Radio Resource Fluctuation for all traffic models should be in the range of 0 to 255.

When Indication Type is set to "PHY report", following attribute lists are valid:

MS MAC Address

48-bit unique identifier of the MS.

Downlink Physical Service Level

Channel rate available for the MS calculated as a multiple of 1/32 of nominal bandwidth in the correspondent direction assuming 1 bit/Hz. For example, if DL channel bandwidth is 10 MHz, value PSL=4 means 4 × 1/32 ×10 Mbps = 1.25 Mbps. 1 PSL 96 (Number of subchannels in different OFDMA modes is multiple of 16 or 32; highest modulation (QAM64) provides 3 bits/Hz)

Downlink RSSI mean

As specified in 8.1.9.

Downlink RSSI standard deviation

As specified in 8.1.9.

Downlink CINR mean

As specified in 8.1.9.

Downlink CINR standard deviation

As specified in 8.1.9.

Uplink Physical Service Level

Channel rate available for the MS calculated as a multiple of 1/32 of nominal bandwidth in the correspondent direction assuming 1 bit/Hz. (see definition of Downlink Physical Service Level)

Uplink RSSI mean

As specified in 8.1.9.

Uplink RSSI standard deviation

As specified in 8.1.9.

Uplink CINRmean

As specified in 8.1.9.

Uplink CINR standard deviation

As specified in 8.1.9.

14.2.13.3.1.3 When generated

This primitive is generated by the BS to notify the NCMS of the periodic/event-triggered report, which is not the immediate response to a C-IM-REQ received from the NCMS.

14.2.13.3.1.4 Effect of receipt

Upper layer entity acquires information of resource management for IM.

14.2.13.3.2 C-IM-IND (Event_Type = IM_CT_Report)

14.2.13.3.2.1 Function

This primitive is generated by the BS to notify the NCMS about the periodic/event-triggered report related to Multi-BS CT for IM, which is not the immediate response to a C-IM-REQ received from the NCMS.

14.2.13.3.2.2 Semantics

C-IM-IND
(
Event_Type: IM_CT_Report,
Destination: NCMS,
Attribute_List:
Indication Type,
List of PHY Report Attributes:
(
MS MAC Address,
Temp BSID for PHY report,
Downlink Physical Service Level,
Downlink RSSI mean,
Downlink RSSI standard deviation,
Downlink CINR mean,
Downlink CINR standard deviation,
Uplink Physical Service Level,
Uplink RSSI mean,
Uplink RSSI standard deviation,
Uplink CINR mean,
Uplink CINR standard deviation
)
)

Indication Type
Type of report profiles:
PHY Report

When Indication Type is set to “PHY Report”, following attribute lists are valid:

MS MAC Address
48-bit unique identifier of the MS.

Temp BSID for PHY report
Member identifier of the Multi-BS CT set for PHY report

Downlink Physical Service Level
Channel rate available for the MS calculated as a multiple of 1/32 of nominal bandwidth in the correspondent direction assuming 1 bit/Hz. For example, if DL channel bandwidth is 10 MHz, value PSL=4 means 4 × 1/32 ×10 Mbps = 1.25 Mbps. 1 PSL 96 (Number of subchannels in different OFDMA modes is multiple of 16 or 32; highest modulation (QAM64) provides 3 bits/Hz)

Downlink RSSI mean
As specified in 8.1.9.

Downlink RSSI standard deviation
As specified in 8.1.9.

Downlink CINR mean
As specified in 8.1.9.

Downlink CINR standard deviation

As specified in 8.1.9.

Uplink Physical Service Level

Channel rate available for the MS calculated as a multiple of 1/32 of nominal bandwidth in the correspondent direction assuming 1 bit/Hz. (see definition of Downlink Physical Service Level)

Uplink RSSI mean

As specified in 8.1.9.

Uplink RSSI standard deviation

As specified in 8.1.9.

Uplink CINRmean

As specified in 8.1.9.

Uplink CINR standard deviation

As specified in 8.1.9.

14.2.13.3.2.3 When generated

This primitive is generated by the BS to notify the NCMS of the periodic/event-triggered report, which is not the immediate response to a C-IM-REQ received from the NCMS.

14.2.13.3.2.4 Effect of receipt

Upper layer entity acquires information of Multi-BS CT for IM.

14.2.13.3.3 C-IM-IND (Event_Type = IM_CT_Indication)

14.2.13.3.3.1 Function

This primitive is generated by the MS to notify the NCMS about the reception of IM_CT-RSP message from the serving/anchor BS.

14.2.13.3.3.2 Semantics

C-IM-IND

(

Event_Type: IM_CT_Indication
Destination: NCMS,
Attribute_List:
Operator ID,
Indication Type,
Anchor Temp BSID,
N_Temp_ID,
for all BSs in the Multi-BS CT set:
Temp BSID,
N_CID
for all connection in the Multi-BS CT set:
CID

)

Operator ID

Identifier of the network provider

Indication Type

Type of indication; bitmap:
- Bit 0: Anchor BS update
- Bit 1: Multi-BS CT candidate set update
- Bit 2: CID update during anchor BS update or Multi-BS CT candidate set update
- Bit 3: Temp BS ID update

Anchor Temp BSID
Temp BSID of the anchor BS, which is the member ID of the Multi-BS CT set.

N_Temp_ID
The counter of the Temp BSID.

Temp BSID
Member identifier of the Multi-BS CT candidate set.

N_CID
The counter of the CID.

CID
Connection identifier

14.2.13.3.3.3 When generated

This primitive is generated by the MS to notify the NCMS of IM_CT-RSP contents received from the serving/anchor BS.

14.2.13.3.3.4 Effect of receipt

Upper layer entity acquires information of Multi-BS CT for IM.

Insert the following new subclause 17

17. Support for Multi-tier Networks

17.1 General

A small BS is a base station controlled by at least one macro BS or an ASN gateway, with smaller transmission power/cell size than that of the macro base station. Small BSs provide different cell coverage and perform different roles according to their types. For example, a Femto BS is typically installed by a subscriber in the home or SOHO to provide the access to closed or open groups of users as configured by the subscriber and/or the access provider. The Femto BS is typically connected to the service provider's network via one (or multiple) wired and/or wireless broadband connection (cable, DSL, WirelessMAN-OFDMA systems, etc.)

Small BSs operate in licensed spectrum and may use the same or different frequency as macro BSs. Their coverage may overlap with a macro BS.

Small BSs are intended to serve public users like an Open Subscriber Group (OSG), or to serve a Closed Subscriber Group (CSG), which is a set of subscribers authorized by the small BS owner or the network service provider. CSG can be modified by the service level agreement between the subscriber and the network service provider.

17.1.1 Small BS subscription types

A small BS may belong to one of the following subscription types:

a) CSG-Closed small BS: A CSG-Closed small BS is accessible only to the MSs, which are in its CSG, except for emergency services. MSs that are not the members of the CSG, should not try to access CSG-Closed small BSs.

b) CSG-Open small BS: A CSG-Open small BS is primarily accessible to the MSs that belong to its CSG, while other MSs, outside CSG, may also access such small BS, and will be served at lower priority. CSG-Open small BS will provide service to such MSs as long as the QoS of MS in its CSG is not compromised.

c) OSG (Open Subscriber Group) small BS: An OSG small BS is accessible to any MS.

17.1.2 small BS state diagram

A small BS transitions through multiple states during its operation, as illustrated in Figure 15-1. On Power-On, it enters the Initialization State. In this state, procedure like configuration of radio interface parameters and time/frequency synchronization should be performed. After attachment to service provider's core network, which may include synchronization to the Macro BS, it enters the Operational State. In the Operational State, if the small BS becomes unattached to the service providers network or if it fails to meet operational requirements (may include failed synchronization), it reverts to the Initialization State.

In the Operational State, normal and duty-cycle modes are supported. In duty-cycle mode, the small BS reduces radio interface activity in order to reduce interference to neighbor cells. A further functional description of duty-cycle mode of small BS can be found in 17.4.2.

In Standby State, only standby mode is supported. In standby mode, the small BS deactivates its air interface to reduce power consumption and interference to neighbor cells. A further functional description of standby mode of small BS can be found in 17.4.3.

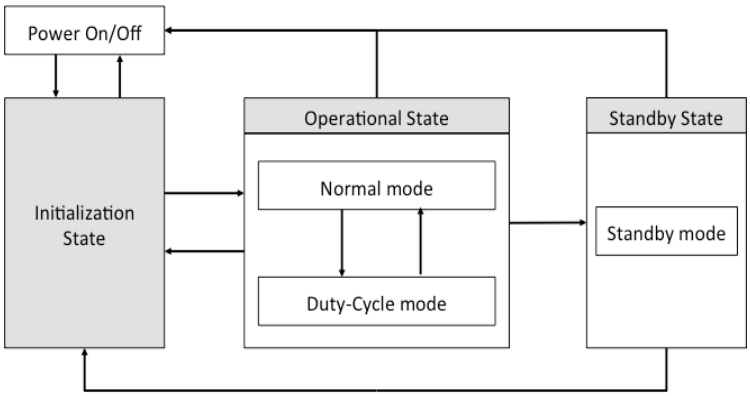

Figure 17-1—Functional overview of small BS states and operational modes

17.1.3 Closed subscription group identifier (CSG ID)

A large number of small BSs may be configured with the same CSG, which has the same group of authorized MSs. A common identifier may be assigned to all CSG small BSs that are part of the same CSG. An MS may use this identifier for accessibility check for the CSG small BSs.

The common identifier, CSG ID, is used to identify the BSs belonging to the same CSG. CSG ID shall be unique within the same operator ID. The CSG ID may be derived from the full BS ID as a part of the BS ID or may be provided by the CSG small BS through DCD message or may be pre-provisioned by the network. How to derive the CSG ID from BS ID is out of scope. The MS's CSG white list may contain the CSG ID and/or BS ID of allowable small BSs.

17.1.3.1 CSG white list

The CSG white list, is a list of small BSs to which the MS is subscribed and can access. These small BSs are identified based on the common identifier defined in 17.1.3.

The MS's local white list may contain the allowable BS IDs or common identifiers of CSGs and relevant information to help derivation of the allowable BS IDs from common identifier. Besides this the whitelist may include absolute/relative location information of CSG small BS, such as GPS information and overlay Macro ABS BSID.

An MS subscribed to CSG(s) should be configured with a CSG White List for its accessibility check. The CSG white list may be provided to the MS by the service provider through the network using messaging that is outside the scope of this standard.

17.1.4 Small BS initialization and network exit

17.1.4.1 Small BS initialization

The small BS shall perform small BS initialization procedures to register itself to the network and to configure itself through the backhaul connection. The details of small BS initialization procedure including obtain-

ing and configuring small BS air interfaces operation parameters through the backhaul connection are out of scope of this specification.

17.1.4.2 Small BS network exit

The small BS network exit procedure is performed through the backhaul network and may be triggered either by the small BS or the other network entities. Before powering down or changing to the initialization state, the small BS may first trigger its attached MSs, if any, to handover to the neighbor cells, if feasible, or to proceed with MS network exit procedure. Which of the two procedures for MS the small BS should trigger before network exit depends on the network policy decision which is out of scope of this standard. When the backhaul link of the small BS is down or the connection with the service provider network is lost for a configurable pre-defined time, the small BS shall consider itself de-attached from the network. In such a case, the small BS shall follow the same procedure performed before power down or transition to Initialization State.

17.1.5 Network synchronization

A small BS shall be synchronized with the overlay BS network at least in all cases where interference in UL or DL can occur, where the synchronization means the aligned frame boundary, and the aligned DL / UL split in TDD systems. The network synchronization may be achieved by small BS scanning of the preamble transmitted by the Macro BSs. For this option, if the small BS can successfully detect the Macro BS preamble, it shall synchronize its downlink transmission with the received preamble signal from Macro BSs. The small BS scanning of Macro BS preamble for network synchronization may be performed before small BS activation or during the inactive interval of duty-cycle mode. The small BS may also achieve network synchronization from GPS or backhaul network (e.g., IEEE Std 1588™).

17.1.6 Network entry

The network entry procedure shall be the same as described in 6.3.9 with the exception of procedures described in this subclause.

17.1.6.1 MS network entry with small BS

An MS may prefer its subscribed CSG small BS, while other small BSs may also be chosen as candidates.

During network entry, the MS acquires the BS ID from the DCD message transmitted by the detected small BS. In addition to the BS ID, the MS may also acquire CSGID and BS subscription type[TBD] from the DCD message. BSID or the acquired or derived CSGID is the identifier for the MS to determine whether it is authorized to access to the detected BS, and may help the MS to quickly exclude the CSG small BS to which it is not subscribed. If the MS supports CSG white-list capability, it may have BS IDs of all CSG small BSs to which the MS is subscribed and is authorized to access. If the small BS is excluded, the MS should continue the scanning until a suitable BS is detected.

17.1.6.2 Small BS reselection by the MS

When the MS performs initial network entry or network reentry with a small BS, it first performs initial ranging by sending the RNG-REQ message. The MS may include one or more CSGID(s) as part of the RNG-REQ message to the small BS, if one or more CSGID(s) is(are) provisioned in the MS. If the small BS is a CSG small BS, it may have one or more CSGID(s) provisioned in it as well. If it is an OSG small BS, then there shall be no CSGID provisioned for it.

If the small BS is an OSG small BS, then the small BS ignores the CSGID(s) (if sent by the MS) in the RNG-REQ and goes ahead with the next steps. If the small BS is a CSG small BS, the small BS receives the

RNG-REQ and, if needed, it looks at the received CSGID(s) and checks if it matches with at least one of its CSGID(s). If there is match of the CSGID, then the small BS knows that the MS is a member of the small BS and goes ahead with the next steps.

If the received CSGID(s) from the MS does not match any of the CSGID(s) of the small BS itself, and the small BS is a CSG-Closed small BS, the small BS shall send a RNG-RSP and in the RNG-RSP it indicates the rejection of access for this MS. In order to help the MS to attach to nearby small BSs, the small BS may provide "Redirection Info" to the MS in the RNG-RSP message. The "Redirection Info" consists of the BS ID, preamble index, and center frequency of other nearby cells. Since the small BS can not be sure that the MS is not its member as the MS may not have included all the CSGIDs in its white list in RNG-REQ, the small BS provides its CSGID(s) and sets the Ranging Abort bit=1 with the Ranging Abort Timer = 65535 in the RNG-RSP in this case so that the MS can perform the accessibility check for the small BS.

If there are no CSGIDs included in the RNG-REQ, then the normal network entry procedure as in 6.3.9 applies.

If the small BS has CSGID info of nearby small BSs, then it may filter the "Redirection Info" based on the CSGID(s) provided by the MS in the RNG-REQ message and only provide the OSG small BSs as well as CSG small BSs with matching CSGID(s) to the MS in the "Redirection Info". After receiving the "Redirection Info", the MS may attach to the other candidate BSs.

In case the MS does not support CSG white-list capability or does not have any CSGID(s) provisioned in its CSG white list, the "Redirection Info" may be provided in the REG-RSP message.

17.2 Mobility management

17.2.1 Handover (HO)

This subclause contains the procedures performed during HO. The HO procedures shall be the same as described in 6.3.20 with the exception of procedures specified in this subcluase.

17.2.1.1 Network topology acquisition

17.2.1.1.1 Network topology advertisement

A BS shall periodically broadcast the system information of the neighboring BSs using an MOB_NBR-ADV message. A broadcast MOB_NBR-ADV message may include the information of Open Subscriber Group (OSG) small BSs, but shall not include information of neighbor Closed Subscriber Group (CSG) small BSs.

A serving BS may unicast a list of accessible neighboring small BSs through the MOB_NBR-ADV message. The accessible small BSs may contain CSG-closed small BSs serving CSGs to which the MS belongs to, and CSG-open small BSs. The MS may request the accessible small BS list from the BS by sending the MOB_SCN-REP message.

17.2.1.1.2 MS scanning neighbor small BSs

For neighbor small BSs, an MS performs the scanning procedure as per 6.3.20.1.2 with exceptions described in this subclause. An MS may scan small BSs according to the neighbor FA information TLV included in the broadcast MOB_NBR-ADV message. In addition, an MS may scan allowed small BSs based on the

CSG white list, which may include the absolute or relative location information of the CSG small BS, such as the GPS information or BSID of the overlay macro BS, respectively. Based on location information and/ or speed, the MS may initiate the scanning procedure (see 6.3.20.1.2). For example, the MS may use the absolute or relative location information of the CSG BS to initiate scanning when the distance between the MS and the CSG small BS is less than a pre-configured threshold or the MS detects the overlay macro BS. Details of the threshold configuration are vendor specific and outside the scope of this specification. The MS may request an additional scanning opportunity by sending MOB_SCN-REQ including the detected preamble index and FA information. Upon reception of the MOB_SCN-REQ, the BS shall respond with an MOB_SCN-RSP, which may include a neighbor-accessible small ABS list based on the preamble index and FA information.

When the MS has to scan the small BSs belonging to a CSG, the MS may provide the desired CSGID(s) in the MOB_SCN-REQ message to the serving BS. The serving BS responds with a list of BSs, addressed by full BSID belonging to the requested CSGID(s), with BS's FA, preamble index, in the MOB_SCN-RSP message.

The BS may send an unsolicited MOB_SCN-RSP for the MS to scan the small BS.

After scanning and identifying the existence of any small BSs, the MS may report FA, preamble index or BS IDs and measurement results according to the Trigger conditions included in the DCD message by sending MOB_SCN-REP. The MOB_SCN-REP may contain a neighbor request TLV. If the BS receives the MOB_SCN-REP that contains the neighbor request TLV, the BS unicast an MOB_NBR-ADV message that includes a system information of neighbor small BSs indicated by the neighbor request TLV in the MOB_SCN-REP.

17.2.1.2 Trigger condition definitions

17.2.1.3 HO decision

After a decision of HO, a serving BS recommends target BS list by including one or more possible target BSs in MOB_BSHO-REQ or MOB_BSHO-RSP messages. In case of macro BS only networks, serving BS criteria for recommendation of target BS may include factors such as expected MS performance at potential target BS, BS and network loading conditions, and MS QoS requirements. In case of multi-tier networks, serving BS criteria for recommendation of target BS may also include MS BS type preference, CSG membership, and MS moving speed in addition to the criteria above.

An MS may access unsubscribed CSG-Open small BS if no candidate BSs are available at the MS after scanning macro BS and accessible small BSs.

17.2.1.4 HO from Macro BS to small BS

When an MS performs HO from a macro BS to a small BS, the MS shall follow the procedure in 6.3.20 with the exceptions as defined in 17.2.

17.2.1.5 HO from small BS to Macro BS

When an MS performs HO from a macro BS to a small BS, the MS shall follow the procedure in 6.3.20.

17.2.1.6 HO between small BSs

When an MS performs HO from a macro BS to a small BS, the MS shall follow the procedure in 6.3.20 with the exceptions as defined in 17.2.

17.2.2 Idle mode

Asmall BS may support idle mode.

A small BS that supports idle mode shall follow the same procedure as specified in 6.3.22 for macro BSs with the exceptions given in this subclause.

A CSG-Closed BS shall not broadcast paging for a non-member MS.

An MS with CSG white list shall not attach to an unsubscribed CSG-Closed small BS in Idle mode.

17.3 Interference management

In multi-tier networks, a small cell overlaid by macro cell(s) may cause severe cross-tier interference to the macro cells, vice versa. A small cell may also cause cross-tier interference to macro cell(s), which are even not overlaying the small cell but adjacent to it, vice versa. In addition, a small/macro cell may generate co-tier interference to adjacent small/macro cell(s). In order to mitigate such interference among cells, mechanisms for resource management and multi-BS MIMO are provided in perspectives of interference mitigation.

17.3.1 Resource Management

The interference between small cells, and between macro cells and small cells may be mitigated by radio resource reservation and resource sharing using time-division and/or frequency-division resource management and/or downlink power control.

As a result of physical channel measurement and report by an MS, the BS reports the channel measurement to the coordinator (e.g., interference management network entity), if certain condition is met. In addition, the BS may report the traffic load. The coordinator, which receives the information such as channel measurement and traffic load, may configure the resource usage. Upon deciding the operation the resource management, management interface and procedure to perform cooperation and to manage resource cooperatively by multiple BSs shall be supported through C-SAP/M-SAP via backhaul link.

17.3.1.1 Fractional Frequency Reuse (FFR)

17.3.1.1.1 DL FFR

DL FFR allows different frequency reuse factors, different frequency partitions for each frequency reuse factor, and different transmit power levels on each frequency partition to enhance resource reuse and network throughput.

Based on the channel measurement from MS and report the result from BS to the coordinator, the coordinator may (re-)configure the partitioning information such as used and non-used subchannels, limited transmit power, and etc. If the DL resource is not partitioned currently, the corresponding zone may be partitioned using the partitioning information. Otherwise, the corresponding zone may be re-partitioned using the partitioning information. Configured partitioning information shall be exchanged through C-SAP/M-SAP via backhaul link.

When the usage of the subchannels in a DL zone is limited by a bitmap, all subcarriers including pilot subcarriers in the corresponding zones (i.e., segments in PUSC and physical bands in AMC) shall be boosted as described in 8.4.9.6 and are allocated to the segment in the DL. The bitmaps that limit subcarrier usage are “Used subchannel bitmap” in the FCH that applies to the first DL PUSC zone and to PUSC zones in which

Use all SC field is set to ‘0’, “DL AMC allocated physical bands bitmap”, “TUSC1 permutation active subchannels bitmap”, and “TUSC2 permutation active subchannels bitmap” TLVs in the DCD.

When the subchannels in a DL zone are not limited by a bitmap (i.e., all subchannels bitmap is set to “1”), any subchannels in the corresponding zones are allowed to allocate resource to MSs. In addition, PUSC zones with all SC field is set to ‘1’ may be used to allocate resource to MSs. In the corresponding zone, the data to transmit to MSs shall be defined by the DL-MAP IE and/or “DL region definition” TLV in DCD.

In a DL frequency partition zone, the corresponding zone may also be further time-division multiplexed and/or frequency-division multiplexed. How to operate is FFS.

17.3.1.1.2 UL FFR

UL FFR allows different frequency reuse factors, different frequency partitions for each frequency reuse factor, and different maximum per-tone power levels on each frequency partition to enhance resource reuse and network throughput.

When the usage of the subchannels in a UL zone is limited by a bitmap, all subcarriers including pilot subcarriers in the corresponding zones (i.e., segments in PUSC and physical bands in AMC) shall be used to allocate to the segment in the UL. The bitmaps that limit subcarrier usage are “UL allocated subchannels bitmap”, “Optional permutation UL Allocated subchannels bitmap”, and “UL AMC Allocated physical bands bitmap” TLVs in the UCD. The partitioning information (including allowed subchannels bitmap and etc.) shall be exchanged through C-SAP/M-SAP via backhaul link.

When the usage of the subchannels in a UL zone is not limited by a bitmap, any subchannels are allowed to allocate bandwidth to MSs. The partitioning information (including used/not used subchannels, limited per-tone power level, and etc.) shall be exchanged through C-SAP/M-SAP via backhaul link.

In a UL frequency partition zone, the corresponding zone may also be further time-division multiplexed and/or frequency-division multiplexed. How to operate is FFS.

17.3.1.2 Time-Division Multiplexed Resource Scheduling

Based on the channel measurement from MS and report the result from BS to the coordinator, the coordinator may (re-)configure the partitioning information such as used and non-used OFDMA symbols for zone boundary. If the DL resource is not partitioned currently, the corresponding zone may be partitioned using the partitioning information. Otherwise, the corresponding zone may be re-partitioned using the partitioning information. Configured partitioning information shall be exchanged through C-SAP/M-SAP via backhaul link.

When the usage of the OFDMA symbols in a DL/UL frame is limited, as a result of coordination among BSs, the corresponding partition is blocked to allocate resource to subordinate MSs. A DL and UL Zone Switch IE or the start of the DL and UL frame shall indicate the start of DL and UL partition, respectively. The DL and UL corresponding partition shall span continuous OFDMA symbols until terminated by another Zone Switch IE or the end of the DL and UL frame, respectively.

In a TDM partitioned zone, the corresponding zone may also be further time-division multiplexed and/or frequency-division multiplexed.

A DL frame or a DL subframe is classified to resource allocation region, empty region and zero energy region, where the allocated portion to be occupied by data traffic and control signal such as FCH, MAP messages is referred to resource allocation region, the portion to be empty is referred to empty region, and a part or whole part of empty region is referred to zero energy region in which a BS does not transmit any signal.

The resource allocation region of a frame may include multiple zones (such as PUSC, FUSC, Optional FUSC, AMC, TUSC1, TUSC2, etc.). The empty region has no any data traffic or control signal, but it may have the subcarriers to be modulated as reference signal such as common pilot to be used as a DL channel measurement for MSs. The BS may be requested for the transmission power of radio signal such as common pilot in empty region.

In zero energy region, a BS shall not allocate, modulate and transmit any radio signal such as data subcarrier and common pilot, and then it may turn off the power of BS transceiver devices as a silent interval in DL transmission. The DL-MAP IE with DIUC = 13 as gap.safety zone indicates that the zero energy region is assigned in a DL frame or a DL subframe. The MS shall ignore any received signal and shall not perform measurement in this region.

A DL frame or a DL subframe can be normally configured to the resource allocation region and the empty region. In some cases, a DL frame or a DL subframe may be configured to different combinations with three regions of resource allocation region, empty region and zero energy region or two regions of resource allocation region and zero energy region. For interference mitigation of DL, the BS may make the best use of empty region to zero energy region. For example, if a BS has not heavily loaded with data traffic, it may convert empty regions to the zero energy region in next frames for the interference mitigation. Both the resource allocation region and the zero energy region can be assigned to one region or more in a DL frame or a DL subframe.

For interference mitigation, one or more different regions may be scheduled among BSs. This is intended to provide reduced interference zones within the coverage area of a BS. The reduced interference zones are useful when the BS interfere with other BS. In such situations, the reduced interference zones may be used by the interfered BS to transmit data to MS that are registered with it, which would otherwise suffer from interference.

If a BS suitably arranges the resource allocation region and the zero energy region by cooperation among neighbor BSs, it is possible to enhance the interference mitigation. Also the BS can additionally get the effect of the BS transmission power saving in DL.

If it is needed to arrange the regions in a frame in order to interference mitigation among BSs in multi-tier networks or enhance BS power saving, the cooperative procedures such as region configuration are performed between the BS and NCMS.

17.3.1.3 Trigger Conditions

A S-BS may send the BS_ID(s) to a subordinate MS and request the MS to scan the corresponding BS(s). The MS scans and reports the channel measurement result to the S-BS, if certain conditions are met. Based on the channel measurement report from the MS, the S-BS and its interfering BS(s) may perform resource management for interference mitigation, as a result of cooperation. How to cooperate among BSs is FFS.

17.3.2 Multi-BS cooperative transmission

Multi-BS cooperative transmission(CT) including Multi-BS diversity and Multi-BS MIMO techniques improves sector throughput and cell-edge throughput through multi-BS cooperative signaling. Multi-BS MIMO includes DL single-BS precoding with multi-BS coordination and DL/UL multi-BS joint processing.

17.3.2.1 DL Multi-BS cooperative transmission

To ensure proper cooperative transmission(CT), each BS capable of providing CT may belong to a certain CT candidate set. Within the cooperative transmission candidate set, a set of BS is selected as a cooperative

transmission set and a common zone is assigned for those BSs operating cooperative transmission, where those BSs may transmit the same data to certain MS(s), as a result of coordination among BSs. The common zone used by the BSs shall be aligned over the same time-frequency radio resource region.For the Multi-BS CT, the Multi-BS support is indicated in the SBC-REQ/RSP message exchange.

For the MS, which is not capable of Multi-BS CT, the MS and BS capable of proving Multi-BS CT perform the following stages:

- Multi-BS CT Decision: A Multi-BS CT begins with a decision for an MS to receive from multiple BSs at the same time.
- Multi-BS CT Set Selection/Update: An MS may scan the neighbor BS and report the channel measurement result to the BS as defined in 6.3.16 and 6.3.20.1.2. Based on the threshold from the IM coordinator, the BS includes neighbor BSs as a Multi-BS CT candidate set and reports those BS lists to the IM coordinator. Within the CT candidate set, the IM coordinator selects a set of BS as a CT set, and a common zone is assigned for those BSs operating CT, where those BSs may transmit the same data to certain MS(s), as a result of coordination among BSs. The common zone used by the BSs shall be aligned over the same time-frequency radio resource region.
- Multi-BS CT Anchor BS Selection/Update: An MS is required to continuously monitor the signal strength of the BSs that are included in the Multi-BS CT set. The MS shall select one BS as a part of HO as defined in 6.3.20 as the serving BS from the Multi-BS CT set and the serving BS is responsible for the Multi-BS CT Anchor BS.

With the Multi-BS CT supported, the MS capable of Multi-BS CT shall perform the following stages:

- Multi-BS CT Decision: A Multi-BS CT begins with a decision for an MS to receive from multiple BSs at the same time.
- Multi-BS CT Set Selection/Update: An MS may scan the neighbor BS and select BSs that are suitable to be included in the Multi-BS CT candidate set. The MS shall report the selected BSs and the Multi-BS CT candidate set update procedure shall be performed by the cooperation among BSs. Within the CT candidate set, a set of BS is selected as a CT set and a common zone is assigned for those BSs operating cooperative transmission, where those BSs may transmit the same data to certain MS(s), as a result of coordination among BSs. The common zone used by the BSs shall be aligned over the same time-frequency radio resource region.
- Multi-BS CT Anchor BS Selection/Update: An MS is required to continuously monitor the signal strength of the BSs that are included in the Multi-BS CT set. The MS shall select one BS from its current Multi-BS CT set to be the anchor BS and reports the selected anchor BS.

For Multi-BS CT, the transmitting antennas simultaneously transmit the same data using the same time-frequency resource, as a result of coordination among BSs. The total *N* antennas of Multi-BS CT BSs constitute an antenna pool. The coordinator for CT shall perform antenna selection/grouping from the antenna pool. The selected antennas are used to transmit data from multi-BS that operates in Multi-BS CT.

When a BS receives the result of physical channel measurement from an MS, the BS reports the channel measurement results to the coordinator (e.g., interference management network entity). The coordinator, which receives the channel measurement results, may (re-)configure a cooperative transmission. Upon deciding the operation the cooperation transmission, management interface and procedure to perform cooperation and to transmit the same data to the same MS cooperatively by multiple BSs shall be supported through C-SAP/M-SAP via backhaul link.

17.3.2.1.1 Multi-BS CT decision and initiation

For an MS and a BS that support Multi-BS CT, the MS and the BS shall maintain a list of BSs that are involved in Multi-BS CT with the MS. The list is called the Multi-BS candidate set. Among the BSs in the

Multi-BS candidate set, a Multi-BS CT anchor BS is defined. When operating in Multi-BS CT, the MS communicates with all BSs in the Multi-BS CT set for DL messages and traffic.

The MS during the Multi-BS CT monitors only the anchor BS for DL control information and DL broadcast messages. In this case, the DL-MAP and UL-MAP transmitted by the anchor BS may contain the burst allocation information for the non-anchor BS in the Multi-BS CT set.

Multi-BS CT begins with a decision for an MS to transmit messages and traffic from multiple BSs at the same time interval. For Multi-BS CT, two or more BSs provide synchronized transmission of MS DL data so that Multi-BS diversity, single-BS precoding with multi-BS coordination, or multi-BS joint processing can be performed by the MS.

The BS supporting Multi-BS CT shall broadcast the DCD message that includes the CT_Add Threshold and CT_Delete Threshold. These thresholds may be used by an MS to determine if IM_CT-REQ should be sent. To measure the physical channel and manage by the coordinator, Temp BSID is assigned to each BS in the Multi-BS CT candidate set. When long-term CINR of an BS in the current Multi-BS CT candidate set is less than CT_Delete Threshold, the MS shall send the corresponding Temp BSID in the IM_CT-REQ to requires dropping this BS from the Multi-BS CT candidate set; when long-term CINR of a neighbor BS is higher than CT_Add Threshold, the MS shall sent an IM_CT-REQ to require adding this neighbor BS to the Multi-BS CT candidate set. In addition, the physical channel measurement of BSs in the current Multi-BS candidate set are reported using IM_CT-REQ to maintain Multi-BS candidate set.

If an MS is not capable of Multi-BS CT, the MS may measure the physical channel of current serving/anchor BS and its neighbor BS(s) and report the channel measurement result to the BS as defined in 6.3.16 and 6.3.20.1.2.

When a BS receives the report of channel measurement from the MS, the BS reports the BS lists including channel measurement result to the IM coordinator to (re-)group (add to or delete from) the Multi-BS CT candidate set.

The decision to update the Multi-BS CT candidate set may begin with a notification by the MS through the IM_CT-REQ management message or by the BS through the IM_CT-RSP management message. The process of anchor BS update may begin with IM-CT-REQ message from MS or IM-CT-RSP from the anchor BS. In addition, decision to update is performed in the IM coordinator without any notification by the MS or by the BS.

The BSs involving the Multi-BS CT with an MS shall use the same set of CIDs for the connections that are established with the MS. The BS may assign a new set of CIDs to the MS during Multi-BS CT candidate set update through IM_CT-REQ message and IM_CT-RSP message. The BS may also assign a new set of CID to the MS through DSA procedure.

There are several conditions that are required to enable Multi-BS CT between MS and a group of BSs as follows:

- The BSs involving in the Multi-BS CT are synchronized based on a common time source.The frames sent by the BSs involving in the Multi-BS CT at a give time arrive at the MS within the pre-fix interval.
- BSs involving in the Multi-BS CT have synchronized frame structure
- BSs involving in the Multi-BS CT have the same frequency assignment
- BSs involving in the Multi-BS CT shall use the same set of CIDs for the connections that are established with the MS.
- The same MAC/PHY PDUs shall be sent by all the BSs involving in the Multi-BS CT to the MS.

17.3.2.1.2 Multi-BS CT set management

The MS may evaluate the possible list of BSs through the received MOB_NBR-ADV message, and previously performed signal strength measurement, propagation delay measurement, scanning, ranging, and association activity. When SCN-REP or IM_CT-REQ is sent by an MS, the BS may report the possible list of BSs including the measured signal strength to the IM coordinator if the conditions are met as follows:

- If the BS receives SCN-REP or IM_CT-REQ from an MS
- If the receive result is different from previous value, which increases or decreases by more than that of the threshold.
- If the timer expires (periodic report)

The IM coordinator decides/updates the Multi-BS CT candidate set based on the report result from the BS. Then, the IM coordinator announces the BSs belong to the Multi-BS CT candidate set. The Multi-BS CT set is a subset of the listed in the Multi-BS CT candidate set.

When IM_CT-REQ is sent by an MS, the IM_CT-REQ may include a possible list of BSs recommended to be included in the MS's Multi-BS CT set. When IM_CT-RSP is sent by the anchor BS or BSs in the MS's current Multi-BS CT candidate set, the BSs may provide a list of recommended BSs for incorporation into the MS's Multi-BS CT candidate set. The Multi-BS CT set is a subset of the listed in the Multi-BS CT candidate set, which is transmitted in the IM_CT-RSP message.

17.3.2.1.3 Multi-BS CT Anchor BS management

When the Multi-BS CT begins, current S-BS is defined as the Multi-BS CT Anchor BS. During the Multi-BS CT operation, the preferred anchor BSs shall be within the current Multi-BS CT set of the MS. The MS may select the preferred anchor BS through the previously performed signal strength measurement. The BS received the result of the signal strength measurement reports it to the IM coordinator (e.g., IM network entity). The IM coordinator, which receives the signal strength measurement result, may select a BS as the Multi-BS CT Anchor BS of the MS and transmits the information of the BS to the current Multi-BS CT candidate set.

17.3.2.1.4 SCT encoding/decoding for Multi-BS CT

In the Multi-BS CT, STC-encoded signals are transmitted across the transmitting antennas using the same time-frequency resource (refer to 8.4.8 for a list of valid STCs). Figure 17-2 is an example of local STC encoding at BS performing Multi-BS CT, where the STC Encoder is identical to the encoder in Figure 8-90 of 8.4.8.1. The unselected antennas are not used for the transmission, but they may be used for other transmission.

In a STC DL Zone with STC not set to "0b00", the BS operated in Multi-BC CT shall perform STC encoding locally by using the STC Matrix as defined by STC_DL_Zone_IE (or MIMO DL Basic IE or MIMO DL Enhanced IE or HARQ MAP) for its assigned antenna number(s), configured by the IM coordinator. The pilot patterns for each BS antenna shall be based on the permutation, the number of antennas as indicated in STC_DL_Zone_IE, and the antenna assignment. The antenna assignment shall be effective until the next configuration from the IM coordinator.

An MS shall demodulate signal in the same procedure as define in 8.4.8. If an MS does not receive MIMO_in_Another_BS_IE() or Macro_MIMO_DL_Basic_IE(), the same data are transmitted from multiple BSs in the same data regions, and then the MS performs RF or diversity combining.

MS shall perform soft data combining when it receives MIMO_in_Another_BS_IE(). In this case, the same data are transmitted in the same or different data region.

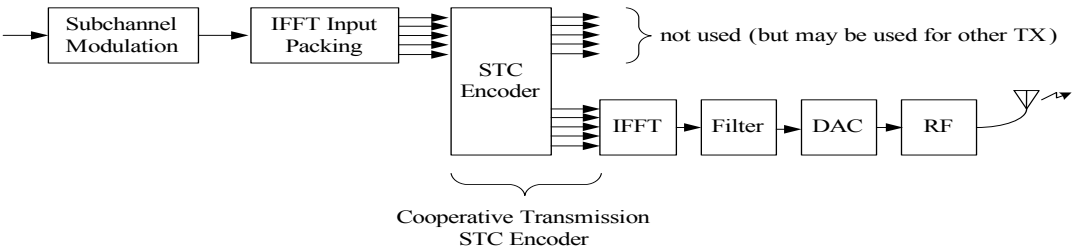

Figure 17-2—A logical block example of local STC encoding for Multi-BS CT at BS

17.3.2.1.5 Multi-BS diversity

A DL zone may be a coordinated zone between the serving BS and its neighbor BSs that have the same zone boundary, the same zone permutation type e.g., PUSC, STC PUSC, AMC, and STC AMC, and the same values for the parameters, Use All SC and Dedicated Pilots, defined by STC DL Zone IE as shown in Table 8-123. In the coordinated zone, an MS receives a data transmission from multiple BSs in the same data regions or different data regions. Operation for the data transmission is FFS.

17.3.2.1.6 DL single-BS precoding with multi-BS coordination

When DL single-BS precoding with multi-BS coordination is enabled, interference from adjacent BSs is mitigated by coordinating the precoders applied in the adjacent BSs.

17.3.2.1.7 DL multi-BS joint processing

When DL multi-BS joint processing is enabled, radio resource allocation, data mapping, and pilot pattern allocation shall be aligned among coordinating BSs. The same data packet is transmitted by the coordinating BSs on the same time and frequency resources.

17.3.2.1.8 Channel feedback for closed-loop transmit precoding

17.3.2.1.8.1 Sounding-based feedback

[*Note: In this subclause, operations of sounding-based feedback will be provided to support DL multi-BS MIMO.*]

17.3.2.1.8.2 MIMO-coefficient-based feedback

[*Note: In this subclause, operations of MIMO-coefficient-based feedback will be provided to support DL multi-BS MIMO when MIMO midamble is supported.*]

17.3.2.1.8.3 Codebook-based feedback

[*Note: In this subclause, operations of codebook-based feedback will be provided to support DL multi-BS MIMO when MIMO midamble is supported.*]

17.3.2.1.8.4 Antenna-selection/grouping-index-based feedback

[*Note: In this subclause, operations of antenna-selection/grouping-index-based feedback will be provided to support DL multi-BS MIMO when MIMO midamble is supported.*]

17.3.2.1.9 Channel quality measurement and report

An MS may measure and report the channel quality of the serving BS and its neighbor BS(s). When a BS capable of providing cooperative transmission receives the report of the channel quality from the MS, the BS reports the channel quality the to the coordinator, if certain conditions are met. Reported channel quality by the BS includes the channel quality of the BS itself and the neighbor BS(s).

When an S-BS requests a subordinate MS to scan the neighbor BS(s) which are participating in cooperative transmission, the MS scans and reports the channel measurement result to the S-BS, if certain conditions are met.

Multi-BS CT BS may instruct the MS to report the channel quality measurement from midamble as defined in 17.3.2.1.9.1.

Multi-BS CT BS may measure the UL channel response and translate the measured UL channel response to an estimated DL channel response when the Tx and Rx hardware are appropriately calibrated. To support DL channel estimation in a mobile environment, sounding based measurement is supported in 17.3.2.1.9.2.

17.3.2.1.9.1 MIMO midamble measurement for Multi-BS CT

Midamble is indicated whether it presents by “midamble presence” in STC DL Zone IE. If midamble is presence in Multi-BS CT, the MS shall measure the physical channel quality measurement from the midamble in the STC zone. Transmit antenna of each BS of Multi-BS CT set is mapped to each transmit in the Multi-BS CT, configured by the IM coordinator.

17.3.2.1.9.2 Sounding based estimation for Multi-BS CT

To support DL channel estimation in a mobile environment, an MS may be instructed to transmit sounding signals periodically. An MS capable of CSIT (as indicated by the SBC-REQ message, see 11.8) transmits channel sounding waveforms as defined in 8.4.6.2.7 on the UL to enable the BS to determine the BS-to-MS channel response under the assumption of TDD reciprocity. To enable sounding based measurement, the anchor BS/serving BS only allocates sounding for the channel based on the cooperation among the anchor BS and its neighbor BSs, where they are in the Multi-BS CT candidate set.

17.3.2.1.10 Trigger conditions

[*Note: In this subclause, trigger conditions for DL multi-BS MIMO will be provided.*]

17.3.2.2 UL Multi-BS MIMO

17.3.2.2.1 UL multi-BS joint processing

When UL multi-BS joint processing is enabled, radio resource allocation, data mapping, and pilot pattern allocation shall be aligned among coordinating BSs. The same data packet is received by the coordinating BSs on the same time and frequency resources.

17.3.2.2.2 Trigger conditions

[*Note: In this subclause, trigger conditions for UL multi-BS MIMO will be provided.*]

17.4 BS power management

17.4.1 General Description

This subclause describes the power management functions of base stations for energy efficient operation. The power management function under this subclause details not only operation of single base station but also cooperative operations of adjacent base stations.

Base stations including macro and small base stations always operate in Normal mode when the base station power management is not supported at the base stations.

Base stations supporting the base station power management described in this subclause operate in one of the power saving operation modes such as Duty-cycled mode or Standby mode when the operation condition is met.

17.4.2 Duty-cycle Mode

Besides the normal operation mode, BSs may support duty-cycle mode to reduce interference to neighbor cells and to conserve its power consumption. The support of duty-cycle mode is negotiated with a BS power controller during the BS initialization and configuration. Duty-cycle mode can be activated through negotiation between the BS and NCMS when the BS is in normal operation mode.

The duty-cycle mode consists of Active Intervals (AI) and Inactive Intervals (IAI). When duty-cycle mode is active for the BS, the BS shall be in either AI or IAI. During the AI, the BS becomes active on the air interface for activities such as paging, transmitting system information, ranging, or data traffic transmission. During the IAI, the BS does not transmit anything on the air interface except DL preamble and may power down one or more physical operation components after the first symbol occupied by the DL preamble or perform other activities such as synchronization with the overlay macro BS or measurement of the interference from neighbor cells. Figure 17-3 depicts an example of frame structure during duty-cycle mode operation.

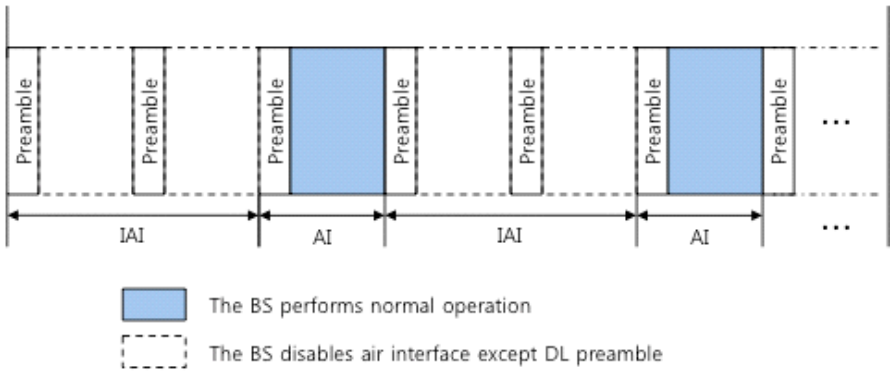

Figure 17-3—Example of frame structure during duty-cycle mode operation

If a BS that supports duty-cycle mode receives a request from a BS power controller to enter duty-cycle mode, it shall respond to the request and perform the operations described below. If there are active MSs connected to the BS when it receives the request, the BS shall perform the BS-initiated handover as specified in 6.3.20.2 to ensure service continuity of the MSs prior to activating duty-cycle mode. After completion of handovers for the MSs, the BS activates duty-cycle mode at Action time specified in the received request. If the handovers are not completed before the Action time or if any MSs cancel or reject the handover requested by the BS, the BS shall transmit a request for cancellation of the duty-cycle mode to the BS power controller and continue to stay in normal operation mode. If there aren't active MSs connected to the BS when the BS receives the request from the BS power controller and there is no new MS that attempts initial network entry or handover to the BS until the Action time, the BS enters duty-cycle mode at the Action time. Otherwise, the BS shall transmit a request for cancellation of the duty-cycle mode to the BS power controller and continue to stay in normal operation mode.

A BS in the duty-cycle mode shall support all available intervals of a paging cycle if it supports idle mode operation. Figure 17-4 provides an example where a BS in the duty-cycle mode supports a single paging cycle.

17.4.2.1 Duty-cycle pattern

A sequence of active and inactive intervals forms a duty-cycle pattern. The duty-cycle pattern is the iteration of one inactive interval and one active interval.

The duty-cycle pattern parameters include the following:

—Length of an active interval (in unit of frames)

—Length of an inactive interval (in unit of frames)

—Start frame offset

The inactive interval starts at the frame number "N",

where N modulo (active interval + inactive interval) == Start frame Offset

Once a BS enters duty-cycle mode, the duty-cycle pattern of the BS is activated. The duty-cycle pattern parameters are assigned by a BS power controller when the BS power controller requests a BS in normal mode to activate the duty-cycle mode or requests a BS in the duty-cycle mode to change the current active duty-cycle pattern.

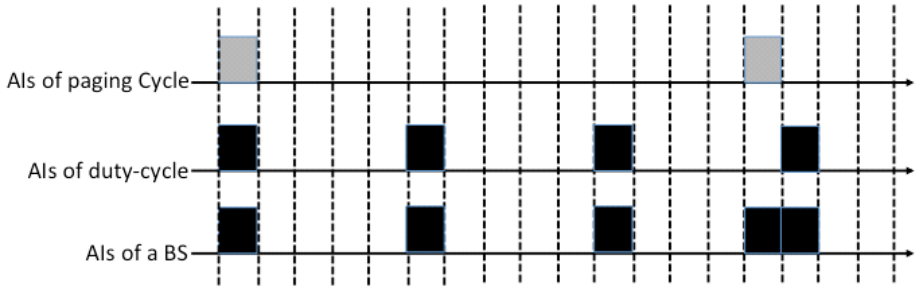

Figure 17-4—Example of operation in duty-cycle mode

17.4.3 Standby Mode

Besides the normal mode and duty-cycled mode, a BS may support standby mode to reduce power consumption and interference to neighbor cell. The BS may enter standby mode if there are no MSs attached to the BS or a small number of MSs are attached to the BS. If the BS enters standby mode, it deactivates its air interface to conserve energy consumption but keep its network interface active to exchange control information with neighbor BSs or network entities.

17.4.3.1 Standby mode initiation

A BS that supports standby mode shall receive configuration information of standby mode from a BS power controller during its initialization or re-configuration phase, prior to operating in normal mode. If a time-based transition included in the configuration information is enabled, the BS shall initiate and terminate the standby mode based on activation and deactivation time included in the configuration information. If an event-based transition included in the configuration information is enabled, the BS shall initiate and terminate the standby mode based on a request from the BS power controller. A BS may support the time-based transition and event-based transition simultaneously.

If the time-based transition is enabled, the BS power controller shall assign activation and deactivation time of the standby mode to the BS. The activation and deactivation time for the BS is determined based on an algorithm that is outside the scope of this standard. This algorithm may use, for example, statistical information on user density, traffic load, interference to/from neighbor cells, etc. Algorithms or policies for determining activation/deactivation time of the standby mode are out of scope of this standard.

If the time-based mode transition is enabled and activation and deactivation time of standby mode is specified during configuration phase, the BS shall activate Standby_Mode_Activation timer with the assigned activation time as soon as it starts normal operation. If only event-based transition is enabled, the BS stays in normal mode until it receives a request from the BS power controller to transit to standby mode.

When the Standby_Mode_Activation timer expires or a request is received from a BS power controller to enter Standby Mode immediately, the BS shall complete the operations described below and disable its air interface. Before disabling the air interface, the BS shall set the cell bar TLV in UCD message to 1 to prevent MS (re)entry and may perform BS-initiated HO procedure as defined in 6.3.20 to hand over active MSs attached to the BS to neighbor BSs. When HO procedures for all MSs attached to the BS are completed, the BS shall disable the air interface and notify the BS power controller of the completion of the mode transition from normal mode to standby mode. If the mode transition is triggered by the expiration of Standby_Mode_Activation timer, the BS shall activate Standby_Mode_Deactivation timer with the deactivation time assigned by the BS power controller during configuration phase as soon as it enters the standby mode.

During standby mode, the air interface of the BS is disabled and the BS does not perform any PHY/MAC operation. But, the BS shall not disable a network interface with neighbor BSs or network entities to perform management operation.

17.4.3.2 Standby mode termination

A BS in standby mode shall go back to normal mode if Standby_Mode_Deactivation timer is expired or it receives a transition request from the BS power controller. The BS shall initialize and activate the air interface before going back to normal mode. The details of the BS initialization procedure including scanning, synchronization and obtaining configuration parameters for the BS air interface operation through the backhaul connection is [TBD]. The BS shall activate Standby_Mode_Activation timer if time-based transition is enabled.

17.4.4 Cooperation of Base Stations for Power Management

The base stations cooperate with other adjacent base stations and/or NCMS (Network Control and Management System) to increase the power saving performance and to prevent the performance degradation (e.g. throughput decreases and coverage holes) due to the power saving operation of base stations.

Insert new Annex R as indicated:

Annex R

(informative)

BS operation mode transition diagram

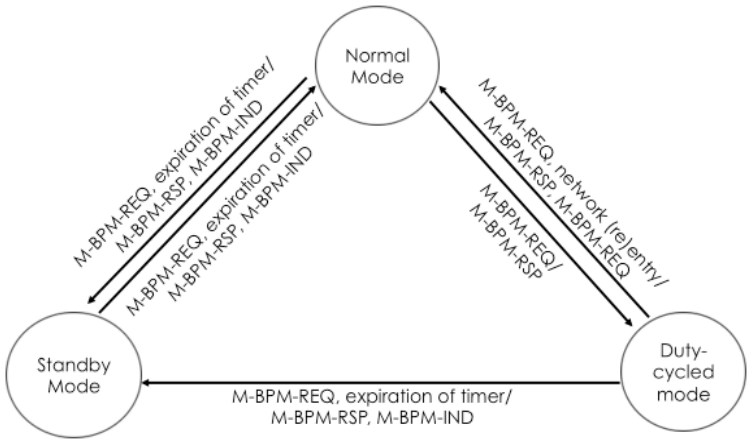

Figure R-1—BS operation mode transition