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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~~**IEEE Microwave Theory and Techniques Society**~~

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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Participants

This document was developend by the IEEE 802.16 Working Group on Broadband Wireless Access, which develops the WirelessMAN® Standard for Wireless Metropolitan Area Networks.

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Harry Bims, *Vice-Chair*

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Primary development was carried out by the Working Group's 802.16q Task Group.

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TBD, Vice Chair

TBD, Secretary

TBD, Editor

The following members of the [individual/entity] balloting committee voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

When the IEEE-SA Standards Board approved this standard on XX Month 2015, it had the following membership:

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Amendment Working Document (AWD) to IEEE Standard

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

6. MAC common part sublayer

6.3.2 MAC PDU formats

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.

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, BPM Configuration, Duty-cycled mode, Standby mode
Destination	M	This indicates the destination of the primitive. Allowed values are: SS or MS, BS, NCMS.
Attribute_list		Array of pair (Attribute_ID, Attribute_value). In Get request operation, Attribute_value is Null

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, Standby_Mode_CMPLT
Destination	M	This indicates the destination of the primitive. Allowed values are: SS or MS, BS, NCMS..
Attribute_list		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.

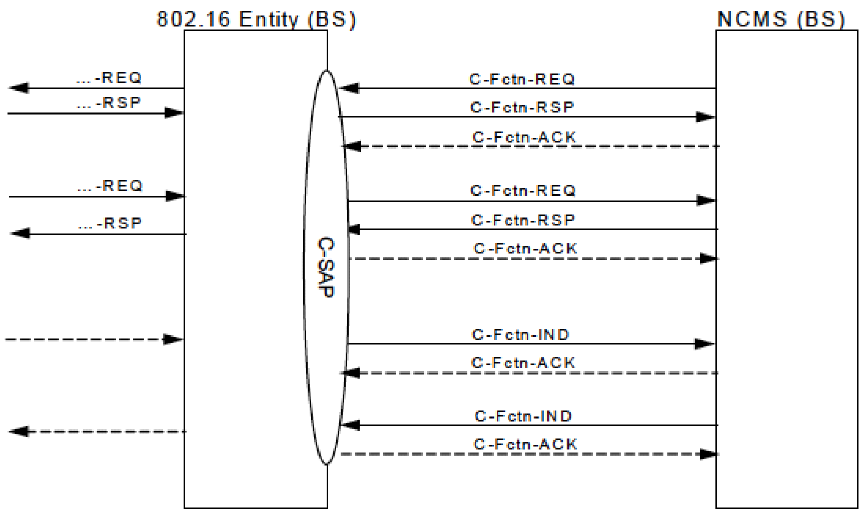

Figure 14-1—SAP service primitive Flow Diagram template

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.

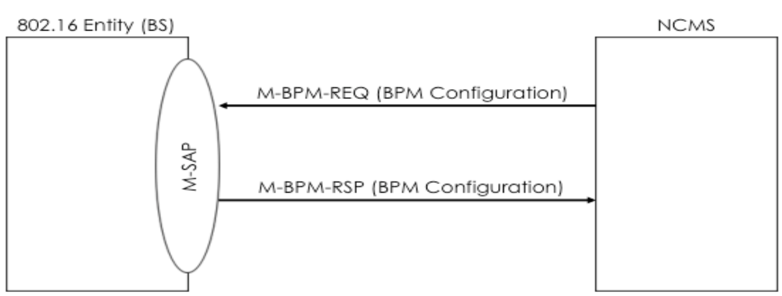

Figure 14-49—Primitive for configuration of BS power management

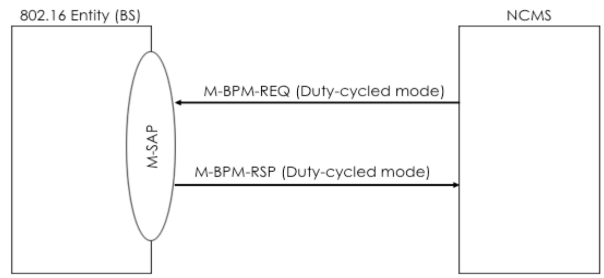

Figure 14-50—Primitive flow for duty-cycled mode transition

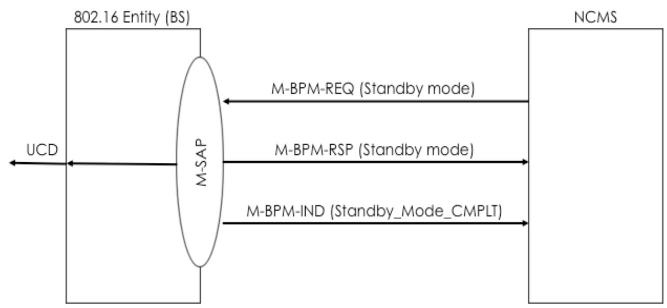

Figure 14-51—Primitive flow for NCMS-initiated standby mode transition

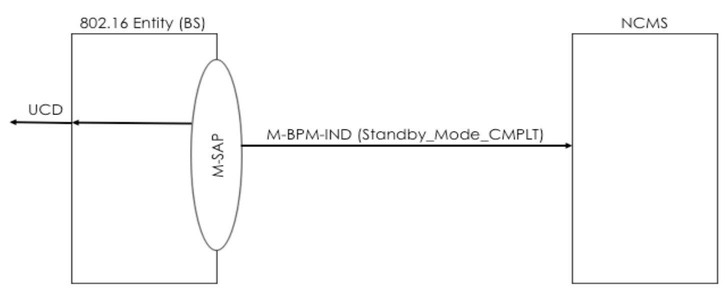

Figure 14-52—Primitive flow for BS-initiated standby mode transition

14.2.12.1 M-BPM-REQ

This primitive is used by the NCMS to configure operation parameters required for BS power management operation or request the IEEE 802.16 entity (BS) to change its operation mode. The possible Action_Types for this primitive are listed in table below:

Action_Type	Description
BPM Configuration	Configuration procedure between BS and NCMS for BS power management
Duty-cycled mode	Duty-cycled mode transition procedure between BS and NCSM.
Standby mode	Standby mode transition procedure between BS and NCMS.

14.2.12.2 M-BPM-RSP

This primitive is used by the IEEE 802.16 entity (BS) 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
BPM Configuration	Configuration procedure between BS and NCMS for BS power management.
Duty-cycled mode	Duty-cycled mode transition procedure between BS and NCSM.
Standby mode	Standby mode transition procedure between BS and NCMS.

14.2.12.3 M-BPM-IND

This primitive is used by the IEEE 802.16 (BS) to inform the NCMS of the completion of standby mode transition. The possible Event_Types for this primitive are listed in table below:

Event_Type	Description
Standby_Mode_CMPLT	Indicating the completion of standby mode transition at the BS.

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 14-53 shows the IM Control Primitives. Further primitive flows are FFS.

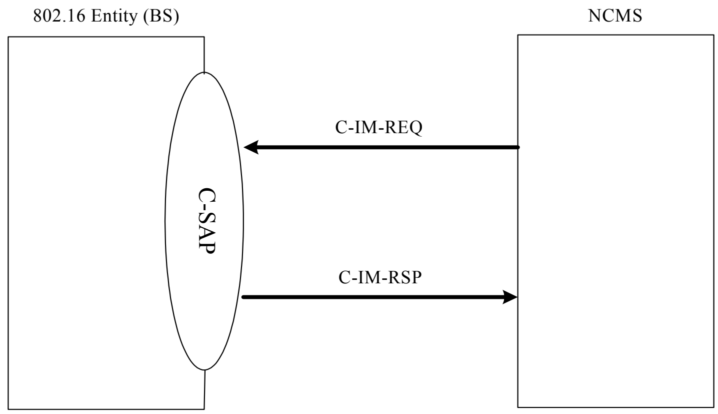

Figure 14-53—Primitive flow of C-IM--REQ/RSP

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 FFS.

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 FFS.

Insert the following new subclause 17

17. Support for Multi-tier Networks

17.1 General

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), but shall not include information of neighbor Closed Subscriber Group (CSG) BSs.

A S-BS may unicast the MOB_NBR-ADV message to an MS upon reception of TBD message or in an unsolicited manner. When the MS needs to obtain the system information of CSG or OSG BS, it may indicate it through the TBD message. Upon receiving this TBD message, the S-BS may send the neighboring CSG or OSG BS information through the MOB_NBR-ADV message to the MS in an unicast manner.

17.2.1.1.2 MS scanning neighbor small BSs

17.2.1.2 Trigger condition definitions

17.2.1.3 HO decision

17.2.1.4 HO from Macro BS to small BS

[*Notes: this subcluase includes HO from Macro BS to OSG small BS as well as HO from Macro BS to CSG small BS*]

17.2.1.5 HO from small BS to Macro BS

17.2.1.6 HO between small BSs

[*Notes: this subcluase includes HO between OSG small BSs as well as HO from OSG small BS to CSG small BS*]

17.2.2 Idle mode

All types of small BSs shall support idle mode by use of the same procedures as specified in 6.3.22 for for macro BSs with the exception of procedures described in this subcluase.

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

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.

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 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, each BS capable of providing cooperative transmission may belong to a certain cooperative transmission 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.

The total *N* antennas of Multi-BS cooperative transmission BSs constitute an antenna pool. The coordinator for cooperative transmission 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 cooperative transmission. The unselected antennas are set to the null transmission. How to select antennas from the antenna pool is FFS.

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 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.

17.3.2.1.2 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.

17.3.2.1.3 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.

17.3.2.1.4 Channel feedback for closed-loop transmit precoding

17.3.2.1.4.1 Sounding-based feedback

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

17.3.2.1.4.2 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.*]

17.3.2.1.4.3 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.*]

17.3.2.1.4.4 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.*]

17.3.2.1.5 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.

17.3.2.1.6 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.

In Normal mode, a BS may allocate the burst in any portion of DL frame or DL subframe, however the BS may not allocate any burst in the rest of the DL frame or the DL subframe. The portion of the frame where bursts are allocated is referred to a resource allocation region and the rest of the frame may be referred to a zero energy region.

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-cycled Mode

Besides the normal operation mode, BSs may support duty-cycled mode to reduce interference to neighbor cells and to conserve its power consumption. Duty-cycled mode is a BS operation mode in which a BS disables its air interface periodically and consists of active periods and inactive periods. The support of duty-cycled mode is negotiated during the BS initialization and configuration. Duty-cycled mode can be activated through negotiation between the BS and NCMS when the BS is in normal operation mode.

When duty-cycled mode is active for the BS, the BS shall be in either active period or inactive period. During an active period, the BS becomes active on the air interface for activities such as paging, transmitting system information, ranging, or data traffic transmission. During an inactive period, the BS does not transmit anything on the air interface and may power down one or more physical operation components or perform other activities such as synchronization with the overlay macro BS or measurement of the interference from neighbor cells.

The base station in the Duty-cycled mode goes into the inactive period when all of its associated mobile stations are in unavailability interval. The inactive period of the base station shall be informed to the mobile stations to prevent UL attempts of mobile stations during inactive period of the base station.

To increase the inactive period of the base station (i.e. a common unavailability interval of mobile stations), base station may adjust the configurations of Sleep mode (i.e. start frame number, window sizes, etc.) of associated mobile stations.

A BS in inactive period shall support an available interval of a paging cycle if it supports idle mode operation.

17.4.2.1 Duty-cycle pattern

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

The duty-cycle pattern parameters include the following:

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

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

—Start frame offset

The active period starts at the frame number “N”, where N modulo (active period + inactive period) == Start frame Offset

Once a BS enters duty-cycled mode, the duty-cycle pattern of the BS is activated. The duty-cycle pattern parameters may be pre-provisioned or unicasted to the MS during initial network entry with the BS in the TBD message. The duty-cycle parameters may be broadcast in the TBD message by the BS when they are changed, for certain duration of time as decided by the network.

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

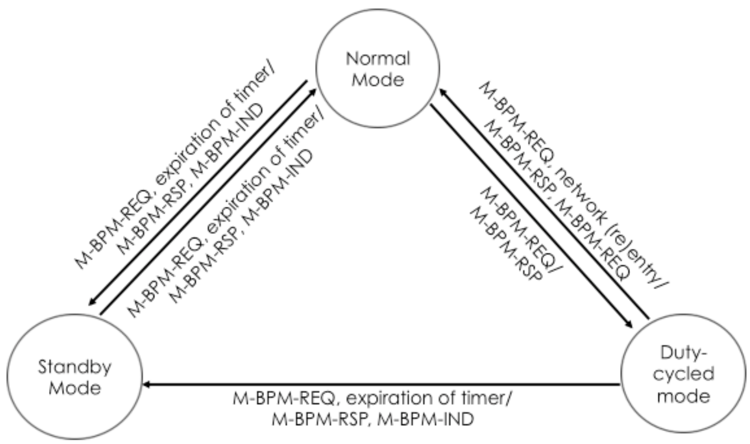

Figure R-1—BS operation mode transition