Project	**IEEE 802.16 Broadband Wireless Access Working Group** <**http://ieee802.org/16**>
Title	**RRM primitives correction**
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Re:	802.16g/D8, section 14.2.6 Radio Resource Management (RRM).
Abstract	**Revision C80216g-07_045r2 includes the changes** agreed during presentation of C80216g-07_045 on March 14: 1) **Delete obsolete "Operation_Type = Action" from section headings** of sections 14.2.6.1.1.1, 14.2.6.1.1.2, 14.2.6.1.2.1, 14.2.6.1.2.2 – hereby also **resolving comment#198** (record 110). 2) **Delete redundant section heading 14.2.6.1 "Radio measurements and reporting"** 3) **Remove the sentence in 14.2.6.1.1:** "The RRC may be located in another BS, or in a central entity in the NCMS." **Note: This contribution also solves comment #199** (record 111). This contribution includes four groups of changes: 1) Adding the missing "When generated" and "Effect of receipt" paragraphs to 14.2.6; 2) Streamlining the list of reporting events for the Spare Capacity report; 3) Adding the Permutation Zone Subchannels Bitmap parameter to the capacity report, as enhancement of the neighbor BS information, and 4) Fixing some editorials.
Purpose	Completing the RRM section 14.2.6, alignment to the other sections 14.2.x as well as to some design decisions taken in the 802.16-related Industry Forum.
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RRM primitives corrections

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Introduction

As said above, this contribution serves four purposes where two of them are straightforward: **1) Filling the gaps** for “When Generated” and “Effect of receipt”, and **4) fixing editorial** bugs.

As to point **3), streamlining the list of reporting events:** This change proposal follows a strategy adopted in the Forum dealing with the 802.16 end-to-end architecture, where the previous long list of RRM reporting events has been replaced by a threshold-based reporting rule: Reports shall be sent whenever the resources change by a certain amount. Such strategy is also proposed here for the RRM C-SAP primitives.

The **fourth change is an improvement of the radio resources reporting** in terms of Permutation Zones. Such reporting is covered by the 802.16g RRM C-SAP primitives so far, but some gaps exist in particular for the case where NCMS is physically deployed in a distributed manner: Allocation of the radio resources used by BS scheduler (MAC CPS) may potentially be decided locally at the BS site. In terms of 802.16g, this may be modeled as a “distributed” deployment of the NCMS and its RRM Controller function. In this case, BS to NCMS signaling turns into BS to BS signaling when talking about real-world BS components.

In order to reduce interference, such neighboring BSs should exchange information concerning the allocated radio resources at the BSs. The basic radio resource is the OFDMA slot. One OFDMA slot is made of one subchannel by one or more OFDMA symbols, depending on the link direction and on the permutation scheme, as defined in section 8.4.3.1 of [802.16e-2005]. Allocated radio resources at the BS can be described therefore in terms of Permutation Zones and allocated Subchannels bitmap. Permutation Zones should preferably be aligned between neighboring BS. Based on aligned Permutation Zones, inter-cell interference can be reduced by proper reuse of subchannels in neighboring BSs.

Specification [802.16g/D8] allows BSs to exchange RRM related information by means of the RRM primitives C-RRM-REQ, C-RRM-RSP in a kind of “pull” model: Any time an updated information is needed, the Radio Resource Control (RRC) entity in the BS can request the information from all neighbouring BSs by means of the message C-RRM-REQ(Action_Type = Spare Capacity Report). The neighboring BSs reply with C-RRM-RSP(Action_Type = Spare Capacity Report), providing details concerning the allocated Permutation Zones.

Since allocation of Permutation Zones is controlled by local BS RRM in a distributed RRM deployment, very frequent message exchanges are needed among neighboring BSs to make sure the information is updated. As a consequence, high signaling load is generated.

This can be remedied by allowing a “push” model where information is delivered unsolicited by help of a suitable trigger. So this contribution proposes to introduce a new trigger event for C-RRM-REQ message. The event is named “Change of Radio Resources Allocation”. By means of this new event the BS requests its Neighbouring BSs to send C-RRM-RSP(Spare Capacity Report) only in case allocation the Permutation Zones or the Subchannels Bitmap at a Neighbouring BS changes. In particular the C-RRM-RSP (Spare Capacity Report) message is sent in case one of the following parameters, already defined in [802.16g/D8], changes at Neighbouring BS:

- N_PERMUTATION_ZONES
- OFDMA symbol offset
- Permutation scheme
- Permutation Zone Subchannels Bitmap

Another gap is the lack of a possibility for a BS to inform neighboring BSs about which subchannels are reserved or preferred for transmission at the BS. Hence collisions in terms of Co-Channel Interference and Adjacent Channel Interference among neighboring BS cannot be avoided. It can be remedied by adding a parameter “Permutation Zone Subchannels Bitmap” to the Spare Capacity report – which so far existed in the “Neighbor-BS Radio Resource Status Update” primitive only.

Proposed Changes to 802.16g/D8: See the revision marks below.

14.2.6 Radio resource management

~~**14.2.6.1 Radio measurements and reporting**~~

…

14.2.6.~~1.~~1 C-RRM-REQ

The Radio Resource Controller (RRC) may use this primitive to request a BS to provide spare capacity information to the RRC or to provide a report of the link level quality for a specific MS. ~~The RRC may be located in another BS, or in a central entity in the NCMS.~~ The possible action ~~type~~types for this primitive are listed in the Table below.

Action Type	Description
Spare Capacity Report	Report the spare capacity information
PHY report	Report the link level quality for a specific MS

~~The following sub-sections define the primitive when its action type is set to a specific action.~~

14.2.6.~~1.~~1.1 C-RRM-REQ (~~Operation Type = Action,~~ Action_Type = Spare Capacity Report)

Function:

This primitive shall be used by NCMS (BS side) to request the BS to send spare capacity information periodically or event driven.

Semantics of the service primitive:

The parameters of the primitives are as follows:

C-RRM-REQ

(
Operation_Type: Action,
Action_Type: Spare Capacity Report,
Destination: BS ~~or NCMS~~,
Attribute List:
Spare Capacity Report Type,
Report Characteristics,
Reporting Period P,
Reporting Threshold RT
)

Spare Capacity Report Type

Type of requested report profile. 1 for spare capacity report type 1. (Types > 1 reserved for future types)

Report Characteristics

Bitmask. Indicates whether report should be sent periodically, or event driven. It also indicates whether the report should include the details about permutation zones and subchannels. Following events are possible (separate or in combination), which may be selected by setting the respective bit:

~~- Completion of Network Entry,~~
~~- Deregistration of MS,~~
~~- Adding / changing / deleting connections,~~
~~- MOB_MSHO-REQ received from MS,~~
~~- MOB_SCAN-REPORT received from MS,~~
~~- Association performed by MS,~~
~~- MOB_HO-IND received by Serving BS,~~
~~- Completion of network re-entry at Target BS after HO,~~
~~- Report solicitation from RRC,~~

- Bit #0: Periodically as defined by reporting period P.
- Bit #1: regularly whenever resources have changed as defined by RT since the last measurement report.
- Bit #2: Reporting shall be given per permutation zones
- Bit #3: Change of Radio Resources Allocation

The event “Change of Radio Resources Allocation” means that a report shall be given whenever any of the following parameters at the BS have changed:

N_PERMUTATION_ZONES
OFDMA symbol offset
Permutation Scheme
Permutation Zone Subchannels Bitmap

Reporting Period P:

The Time P is used by BS (RRA) as the reporting period for producing the information requested by RRC.

Reporting Threshold RT:

The threshold value RT shall be used by BS (RRA) to send another Spare Capacity report as soon as the spare capacity increases or decreases by more than that threshold value.

When generated:

The NCMS at BS side may use this primitive to order a BS to send periodic and/or event-driven radio resource capacity reports.

Effect of receipt:

The BS shall respond with a C-RRM-RSP (Spare Capacity Report) and, if applicable, one or more subsequent periodic or event-driven C-RRM-IND (Spare Capacity Report) primitives.

14.2.6.~~1.~~1.2 C-RRM-REQ (~~Operation Type = Action,~~ Action_Type = PHY report)

Function:

The Radio Resource Controller (RRC) may use this primitive to request a BS to provide a report of the link level quality for a specific MS.

Semantics of the service primitive:

C-RRM-REQ
(
Operation_Type: Action,
Action_Type: PHY Report,
Destination: BS~~ or NCMS~~,
Attribute List:
MS MAC Address
)

MS MAC Address
48-bit unique identifier of the MS

When generated:

The NCMS at BS side may use this primitive at any time to order a BS to report on the PHY channel parameters (RSSI, CINR as well as spectral efficiency as expressed by the Physical Service Level) for a specific MS.

Effect of receipt:

The BS shall generate the required UL channel measurements and shall request the SS via MAC Management messages to send the required DL channel measurement reports to the BS; once the measured values are available, the BS shall forward these to the NCMS (BS side) by a C-RRM-RSP (PHY report) primitive.

14.2.6.~~1.~~2 C-RRM-RSP

The BS may use this primitive to report spare capacity information to the RRC, as requested by the RRC within the Spare Capacity Request primitive. Or the BS may use this primitive to provide a report of the link level quality for a specific MS to the Radio Resource Controller (RRC). The possible action ~~type~~types for this primitive are listed in the Table below.

Action Type	Description
Spare Capacity Report	Report the spare capacity information
PHY report	Report the link level quality for a specific MS

14.2.6.~~1.~~2.1 C-RRM-RSP (~~Operation Type = Action,~~ Action_Type = Spare Capacity Report)

Function:

The BS may use this primitive to provide spare capacity information to the RRC, as requested by the RRC within the Spare Capacity Request primitive. The BS may also use this primitive to inform the RRC about preferred Radio Resources used for transmission at sending BS, using the attribute Permutation Zone Subchannels Bitmap.

Semantics of the service primitive:

C-RRM-RSP
(
Operation_Type: Action,
Action_Type: Spare Capacity Report,
Destination: ~~BS or~~ NCMS,
Attribute List:
Spare Capacity Report Type,
N_PERMUTATION_ZONES,
For all Permutation Zones:
OFDMA symbol offset,
Permutation scheme,
Permutation Zone Subchannels Bitmap,
Available Radio Resource,
Radio Resource Fluctation
)

Spare Capacity Report Type

Type of report profile = 1

N_PERMUTATION_ZONES

Number of radio frame subsections for which the spare capacity 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, in which case the DL/UL Available Radio Resource indicators cover the full DL and UL radio subframes.

OFDMA symbol offset

Denotes the start of the zone (counting from the frame preamble and starting from 0)

Permutation scheme

Denotes permutation scheme used in 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 Subchannels Bitmap

Indicates the subchannels preferred for transmission in this Permutation Zone at the respective BS.

Available Radio Resource

Percentage of reported average available sub channels 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 generated:

The BS shall send this primitive in response to a C-RRM-REQ (Spare Capacity Report) received from the NCMS.

Effect of receipt:

The NCMS may use the received Spare Capacity information about the BSs for several purposes, e.g. for forwarding the aggregated BS capacity information to all the BSs by means of the C-RRM-IND (Neighbor-BS

Radio Resource Status Update) primitive, for Service Flow Admission Control, or for reconfiguring the allocated BS resources.

14.2.6.~~1.~~2.2 C-RRM-RSP (~~Operation Type = Action,~~ Action_Type = PHY report)

Function:

The BS may use this primitive to provide a report of the link level quality for a specific MS to the Radio Resource Controller (RRC).

Semantics of the service primitive:

C-RRM-RSP
(
Operation_Type: Action,
Action_Type: PHY Report,
Destination: ~~BS or~~ NCMS,
Attribute List:
MS MAC Address,
Downlink Physical Service Level,
Downlink RSSI mean,
Downlink RSSI standard deviation,
Downlink CINR mean,
Uplink Physical Service Level,
Uplink RSSI mean,
Uplink RSSI standard deviation,
Uplink CINR mean
)

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 sub channels 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 Channel quality measurements [802.16-2004].

Downlink RSSI standard deviation
As specified in 8.1.9 Channel quality measurements [802.16-2004].

Downlink CINR mean
As specified in 8.1.9 Channel quality measurements [802.16-2004].

Downlink CINR standard deviation
As specified in 8.1.9 Channel quality measurements [802.16-2004].

Uplink RSSI mean

As specified in 8.1.9 Channel quality measurements [802.16-2004].

Uplink RSSI standard deviation

As specified in 8.1.9 Channel quality measurements [802.16-2004].

Uplink CINR mean

As specified in 8.1.9 Channel quality measurements [802.16-2004].

Uplink CINR standard deviation

As specified in 8.1.9 Channel quality measurements [802.16-2004].

When generated:

The BS shall send this primitive in response to a C-RRM-REQ (PHY Report) received from the NCMS, after having retrieved the required PHY channel measurement data.

Effect of receipt:

The NCMS may use the received PHY Report data of the respective MS for any purpose, e.g. as a reason for initiating handovers or service flow modifications.

14.2.6.~~1.~~3 C-RRM-IND

This primitive can be used by RRC to inform a Serving BS about the list of Neighbor BSs which are potential HO Target Base Stations for any MS's being served by the SBS, including an information about their radio resource status. And it can also be used by the RRA to report the spare capacity information to the RRC periodically or as event driven. The possible event ~~type~~ types for this primitive are listed in the Table below:

Event Type	Description
Spare Capacity Report	Report the spare capacity information
Neighbor-BS Radio Resource Status Update	Inform neighbor list BS's list or related information about the radio resource status

14.2.6.~~1.~~3.1 C-RRM-IND (Event_Type = Spare Capacity Report)

Function:

The primitive provides the mechanism to report the spare capacity information to the RRC whenever this is not the immediate response to a ~~beside the~~ report solicitation from RRC.

Semantics of the service primitive:

C-RRM-IND

(
Event_Type: Spare Capacity Report,
Destination: ~~BS or~~ NCMS,
Attribute List:

Spare Capacity Report Type,
N_PERMUTATION_ZONES,
For all Permutation Zones:
OFDMA symbol offset,
Permutation scheme,
Permutation Zone Subchannels Bitmap,
Available Radio Resource,
Radio Resource Fluctuation
)

Spare Capacity Report Type

Type of report profile = 1

N_PERMUTATION_ZONES

Number of radio frame subsections for which the spare capacity 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, in which case the DL/UL Available Radio Resource indicators cover the full DL and UL radio subframes.

OFDMA symbol offset

Denotes the start of the zone (counting from the frame preamble and starting from 0)

Permutation scheme

Denotes permutation scheme used in 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 Subchannels Bitmap

Indicates the subchannels preferred for transmission in this Permutation Zone at the respective BS.

Available Radio Resource

Percentage of reported average available sub channels 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 generated:

The BS shall use this primitive for delivering a periodic or event-triggered Spare Capacity Report which is not the immediate response to a C-RRM-REQ (Spare Capacity Report) received from the NCMS.

Effect of receipt:

The NCMS may use the received Spare Capacity information for any purpose, similarly as in case of a received C-RRM-RSP (Spare Capacity Report).

14.2.6.~~1.~~3.2 C-RRM-IND (Event_Type = Neighbor-BS Radio Resource Status Update)

Function:

This primitive can be used by RRC to inform a Serving BS about the list of Neighbor BSs which are potential HO Target Base Stations for any MS's being served by the SBS, including the information about their radio resource status. This primitive can also be used by RRC in NCMS to enforce a change of the Permutation Zone parameters for a group of BSs. For this purpose, the NCMS may send this C-RRM-IND message to each of the BSs in the group in a synchronized way, thereby informing each BS about i) the Permutation Zone parameters to be used by this BS, and ii) the Permutation Zone Parameters of neighboring BSs, together with an indication about the percentage of still available radio resources in these Permutation Zones. The BS may use this detailed neighbor BS information at the MAC layer for optimized scheduling.

Semantics of the service primitive:

C-RRM-IND
(
Event_Type: ~~(~~Neighbor-BS Radio Resource Status Update~~)~~,
~~Object_id(~~Destination: BS~~ID or NCMS node)~~,
Attribute List:
N_NEIGHBORS,
For all BSs in the BS List:
BSID,
N_PERMUTATION_ZONES,
For all Permutation Zones:
OFDMA symbol offset,
Permutation scheme,
Permutation Zone Subchannels Bitmap,
Available Radio Resource,
Radio Resource Fluctuation,
DCD Configuration Change Count,
UCD Configuration Change Count
)

N NEIGHBORS

Number of neighbor BS's

BSID

Unique identifier of BS

N_PERMUTATION_ZONES

Number of radio frame subsections for which the spare capacity 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, in which case the DL/UL Available Radio Resource indicators cover the full DL and UL radio subframes.

OFDMA symbol offset

Denotes the start of the zone (counting from the frame preamble and starting from 0)

Permutation scheme

Denotes permutation scheme used in 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 this Permutation Zone at the respective BS.

Available Radio Resource

Percentage of reported average available sub channels and symbols resources 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.

DCD Configuration Change Count

This represents the Neighbor BS current Downlink Channel Descriptor (DCD) configuration change count

UCD Configuration Change Count

This represents the Neighbor BS current Uplink Channel Descriptor (UCD) configuration change count

When generated:

The NCMS (BS side) shall use this primitive to forward aggregated Neighbor BS information to each of the BSs which are under control of the NCMS.

Effect of receipt:

The BS shall use the information for updating the MOB_NBR-ADV message at the radio interface. In addition the BS may use the information for improving the efficiency of its MAC and PHY functions.