Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Management of radio resources assigned to neighboring BSs**
Date Submitted	2006-09-13 (rev.1 on 2006-09-26)
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Re:	802.16g/D4, section 14.2.7 Radio Resource Management (RRM). Contribution related to Letter Ballot 20c, comment #3043
Abstract	NCMS should have the means of modifying the radio resources allocated to a BS, to meet varying capacity demand. At the same time, Co-Channel Interference (CCI) between BSs should be minimized. For this purpose, Spare Capacity reports as well as Neighbor BS Radio Resource Status Update messages need to be enhanced. – 052r1 is a simplification compared to 052: Enhancement of existing messages only.
Purpose	Harmonized Radio Resource adaptation to varying demand while keeping Co-Channel Interference (CCI) between neighboring BSs under control.
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Management of radio resources assigned to neighboring BSs

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Introduction

The pool of radio resources used by the scheduler in each BS is composed of a set of Subchannels within "Permutation Zones", where the latter ones are contiguous subsets of the OFDMA slots in each radio frame. Within a Permutation Zone, the mapping of subcarriers to subchannels is constant throughout the respective radio frame section. A formal definition of "Permutation Zone" and related terms is provided in section 8.4.3 of [802.16-2004].

For efficient usage of radio resources, it is desirable to allocate the Permutation Zones and the Subchannels to BSs in a way that Co-Channel Interference (CCI) between neighboring BSs is minimized. The Permutation Zones, i.e. the usable sections of the radio frames of neighboring BSs, should preferably be aligned, and each BS should preferably apply those subchannels which are not used too much by its neighbor BSs.

At the same time, a dynamic reallocation of radio resources to BSs is useful for adaptation to varying capacity demands. The Radio Resource Management (RRM) procedures should allow for dynamic reallocation of resources to BSs while keeping an eye on the intercell CCI.

To this end, this contribution proposes an upgrade of the existing RRM Measurements and Indicators across the C-SAP which allows an RRC entity in NCMS to detect the need for radio resources re-allocation, and to perform re-allocation in a harmonized way within a group of neighboring BSs.

In short, the existing Spare Capacity reports and Neighbor BS update indicators shall optionally be indexed per Permutation Zones, and should also indicate the sub channels where spare capacity is available.

The proposed changes include:

Change #1: For C-RRM-REQ: Addition of a new Reporting Characteristics event by which NCMS can optionally request the BS to send the radio resources report per Permutation Zones.

Change #2: For C-RRM-RSP: Addition of some parameters, including N_PERMUTATION_ZONES, by which the BS can optionally send the radio resources report per Permutation Zones instead of just per DL/UL radio subframe.

Change #3: For C-RRM-IND (uplink, from BS to NCMS): Add a few parameters (the same as added to C_RRM_RSP) to allow repeated reporting of the spare capacity indication per Permutation Zones (periodically or event driven).

Change #4: For C-RRM-IND, in DL direction (from NCMS to BS): Add some parameters which allow the NCMS to reconfigure the Radio Resources to be used by each BS.

Proposed Changes to 802.16g/D4

In the following, the proposed changes are shown by revision marks.

14.2.7 Radio resource management

14.2.7.1 Radio measurements and reporting

The RRM Primitives are a set of primitives for supporting RRM procedures between BS and NCMS.

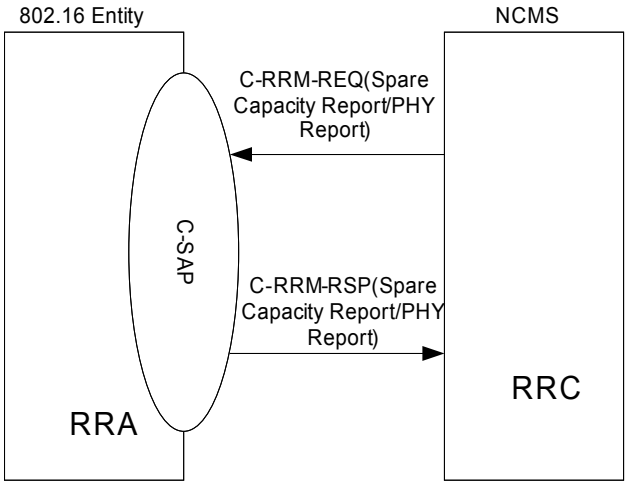

Figure 495 - primitive Flow of C-RRM-REQ/RSP

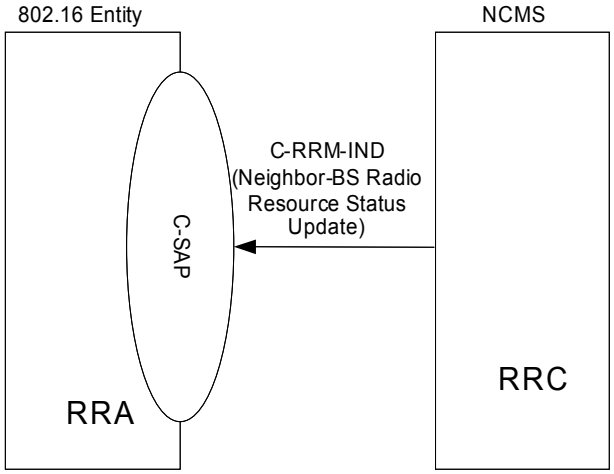

Figure 496 - primitive Flow of C-RRM-IND (Neighbor-BS Radio Resource Status Update)

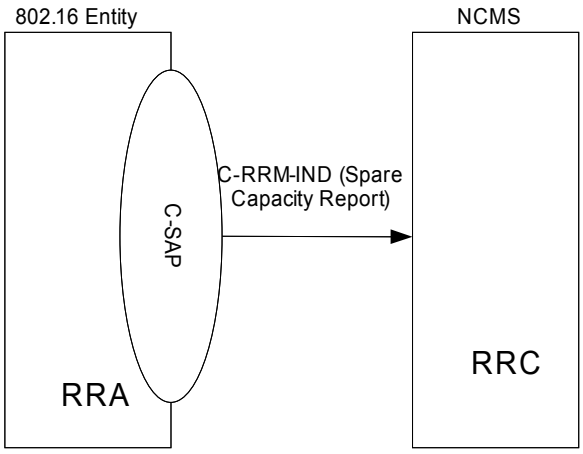

Figure 497 - primitive Flow of C-RRM-IND (Spare Capacity Report))

Change #1: Enhancement of subchapter 14.2.7.1.1.1, C-RRM-REQ:

14.2.7.1.1 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 for this primitive are listed in 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.

14.2.7.1.1.1 C-RRM-REQ (Operation Type ==Action, Action_Type==Spare Capacity Report)

Function:

This primitive shall be used to request the BS send spare capacity information periodically or event driven.

Semantics of the service primitive:

The parameters of the primitives are as follows:

C-RRM-REQ
(
Message_id,
Operation_Type(Action),

Action_Type(Spare Capacity Report),
Object_id(BS_ID or NCMS node),
Attribute List:
Spare Capacity Report Type,
Report Characteristics
)

Spare Capacity Report Type

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

Report Characteristics

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):

- 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
- Reporting per permutation zones

14.2.7.1.1.2 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:

The parameters of the primitives are as follows:

C-RRM-REQ
(
Message_id,
Operation_Type(Action),
Action_Type(PHY Report),
Object_id(BS_ID or NCMS node),
Attribute List:
MS ID
)

MS ID

48-bit unique identifier of the MS

Change #2: Enhancement of subchapter 14.2.7.1.2.1 C-RRM-RSP (Operation Type ==Action, Action_Type==Spare Capacity Report:

14.2.7.1.2 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 for this primitive are listed in 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.

14.2.7.1.2.1 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.

Semantics of the service primitive:

C-RRM-RSP
(
Message_id,
Operation_Type(Action),
Action_Type(Spare Capacity Report),
Object_id(BS_ID or NCMS node),
Attribute List:
Spare Capacity Report Type,
N_PERMUTATION_ZONES
For all Permutation Zones:
OFDMA symbol offset,
Permutation scheme,
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

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. ~~, as defined in section 14.5.13.3~~

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.

14.2.7.1.2.2 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

(

Message_id,
Operation_Type(Action),
Action_Type(PHY Report),
Object_id(BS_ID or NCMS node),
Attribute List:
MS ID
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].

Change #3: Enhancement of subchapter 14.2.7.1.3.1 C-RRM-IND (Event_Type == Spare Capacity Report)

14.2.7.1.3 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 be used to report the spare capacity information to the RRC periodically or event driven. The possible event type for this primitive are listed in 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

14.2.7.1.3.1 C-RRM-IND (Event_Type == Spare Capacity Report)

Function:

The primitive provide the mechanism to report the spare capacity information to the RRC beside the report solicitation from RRC.

Semantics of the service primitive:

C-RRM-IND
(
Message_id,
Event_Type(Spare Capacity Report),
Object_id(BS_ID or NCMS node),
Attribute List:
Spare Capacity Report Type,
N_PERMUTATION_ZONES,
For all Permutation Zones:
OFDMA symbol offset,
Permutation scheme,
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

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~~, as defined in section 14.5.13.3~~

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.

Change #4: Enhancement of subchapter 14.2.7.1.3.2 C-RRM-IND (Event_Type == Neighbor-BS Radio Resource Status Update):

14.2.7.1.3.2 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

(
Message_id,
Event_Type(Neighbor-BS Radio Resource Status Update),
Object_id(BS_ID or NCMS node),
Attribute List:
N_NEIGHBORS,

For all BSs in the BS List:
BS_ID,
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
BS_ID
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.~~, as defined in section 14.5.13.3~~
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

End of Changes