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
Source(s)	Achim Brandt Achim.Brandt@siemens.com Siemens AG
Re:	802.16g/D4, section 14.2.7 Radio Resource Management (RRM). Contribution related to Letter Ballot 20c
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.
Purpose	Harmonized Radio Resource adaptation to varying demand while keeping Co-Channel Interference (CCI) between neighboring BSs under control.
Notice	This document has been prepared to assist IEEE 802.16. It is offered as a basis for discussion and is not binding on the contributing individual(s) or organization(s). The material in this document is subject to change in form and content after further study. The contributor(s) reserve(s) the right to add, amend or withdraw material contained herein.
Release	The contributor grants a free, irrevocable license to the IEEE to incorporate material contained in this contribution, and any modifications thereof, in the creation of an IEEE Standards publication; to copyright in the IEEE's name any IEEE Standards publication even though it may include portions of this contribution; and at the IEEE's sole discretion to permit others to reproduce in whole or in part the resulting IEEE Standards publication. The contributor also acknowledges and accepts that this contribution may be made public by IEEE 802.16.
Patent Policy and Procedures	The contributor is familiar with the IEEE 802.16 Patent Policy and Procedures <http://ieee802.org/16/ipr/patents/policy.html>, including the statement "IEEE standards may include the known use of patent(s), including patent applications, provided the IEEE receives assurance from the patent holder or applicant with respect to patents essential for compliance with both mandatory and optional portions of the standard." Early disclosure to the Working Group of patent information that might be relevant to the standard is essential to reduce the possibility for delays in the development process and increase the likelihood that the draft publication will be approved for publication. Please notify the Chair <mailto:chair@wirelessman.org> as early as possible, in written or electronic form, if patented technology (or technology under patent application) might be incorporated into a draft standard

being developed within the IEEE 802.16 Working Group. The Chair will disclose this
notification via the IEEE 802.16 web site <http://ieee802.org/16/ipr/patents/notices>.

Management of radio resources assigned to neighboring BSs

Achim Brandt
Siemens

Introduction

The pool of radio resources used by the scheduler in each BS is composed of "Permutation Zones" including a contiguous subset of the OFDMA slots in the radio frames. Section 8.4.3 of [802.16-2004] includes a definition of "Permutation Zone" and related terms.

For efficient usage of radio resources, it is necessary to

1) allocate the Permutation Zones to BSs in such a way that the Co-Channel Interference (CCI) between neighboring BS areas is minimized; and

2) being able to dynamically re-allocate Permutation Zones, to meet a potentially varying capacity demand per BS.

Therefore this contribution proposes an upgrade of RRM Measurements and Indicators 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.

The proposed changes include:

Change #1: For C-RRM-REQ: Addition of a new Action Type "Spare Capacity Detailed Report" by which NCMS requests the BS to send the radio resources report per Permutation Zones.

Change #2: For C-RRM-RSP: Addition of the new Action Type "Spare Capacity Detailed Report" by which BS sends the radio resources report per Permutation Zones, as direct response to RRM-REQ.

Change #3: For C-RRM-IND (uplink, from BS to NCMS): Add a new Event Type "Spare Capacity Detailed Report", to allow repeated reporting of the new indication (periodically or event driven).

Change #4: For C-RRM-IND, in DL direction (from NCMS to BS): Add a new Event Type "Neighbor-BS Permutation Zones Status Update" which allows 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.
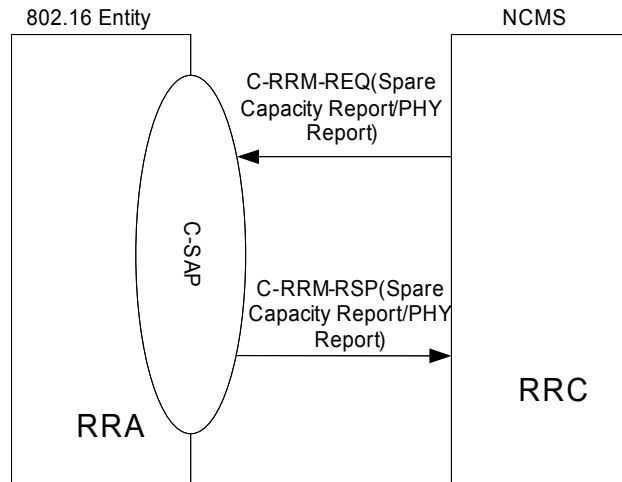
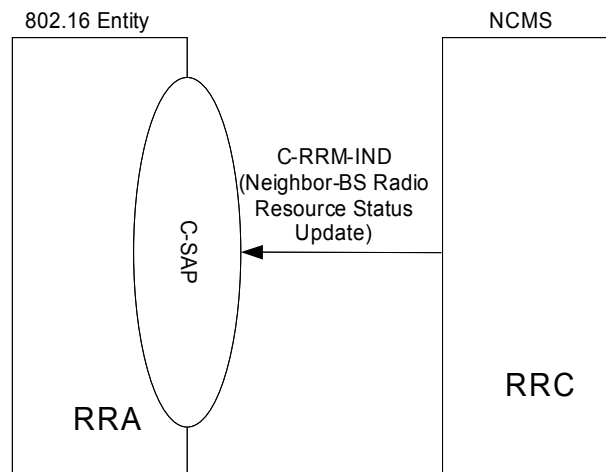**Figure 495 - primitive Flow of C-RRM-REQ/RSP**

Figure 496 - primitive Flow of C-RRM-IND (Neighbor-BS Radio Resource Status Update)
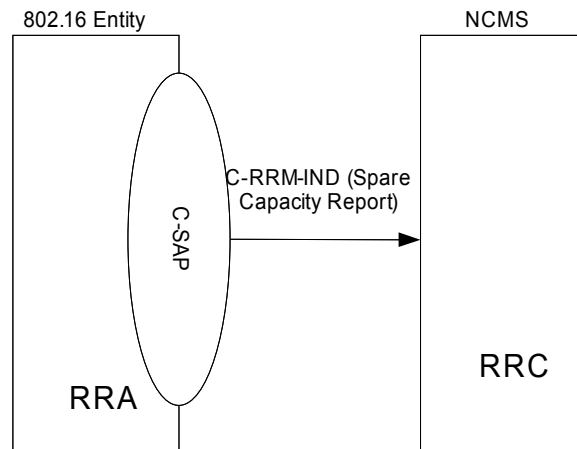
Figure 497 - primitive Flow of C-RRM-IND (Spare Capacity Report))

Change #1: Insert subchapter 14.2.7.1.1.3 C-RRM-REQ (Operation Type ==Action, Action_Type==Spare Capacity Detailed Report) into 14.2.7.1.1

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
Spare Capacity Detailed Report	Report the spare capacity information for a list of "Permutation Zones"

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. Following events are possible:
>> - 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

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

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

Function:

This primitive shall be used to request the BS send spare capacity information periodically or event driven. "Detailed" reporting means that the BS shall report the spare resources for all the Permutation Zones used by the BS.

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

The definition of the parameters in the Attrubute List is the same as for Action Type(Spare Capacity Report).

Change #2: Insert subchapter 14.2.7.1.2.3 C-RRM-RSP (Operation Type ==Action, Action_Type==Spare Capacity Detailed Report) into 14.2.7.1.2

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
Spare Capacity Detailed Report	Report the spare capacity information for a list of

"Permutation Zones"

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,
> > > Available Radio Resource,
> > > Radio Resource Fluctation
> >)

> **Spare Capacity Report Type**
> > Type of report profile = 1
> **Available Radio Resource**
> > Percentage of reported average available sub channels and symbols resources per frame, 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. 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].

14.2.7.1.2.3 C-RRM-RSP (Operation Type ==Action, Action_Type==Spare Capacity Detailed Report)

Function:

The BS may use this primitive to provide "detailed" spare capacity information to the RRC (i.e. a list of spare capacity indications in terms of Permutation Zones), as requested by the RRC within the Spare Capacity Detailed Request primitive.

Semantics of the service primitive:

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

The parameters in the attribute list are defined as follows:

        N_PERMUTATION_ZONES
                Number of Permutation Zones in total for DL and UL subframes at this BS.
        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 Permutation Zone Radio Resources
                Percentage of reported average available subchannels and symbols resources per permutation zone.
        Permutation Zone Radio Resource Fluctuation
                Permutation Zone Radio Resource Fluctuation is used to indicate the degree of fluctuation in DL

or UL, resp., channel data traffic throughputs for the current Permutation Zone. Value range is the same as for "Radio Resource Fluctuation".

Change #3: Insert subchapter 14.2.7.1.3.3 C-RRM-IND (Event_Type == Spare Capacity Detailed Report) into 14.2.7.1.3

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
Spare Capacity Detailed Report	BS to NCMS: Report the spare capacity information for a list of "Permutation Zones"
Neighbor-BS Permutation Zones Status Update	NCMS to BS: Modify the BS's Permutation Zones and inform the BS about Permutation Zones of neighbor BSs.

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,
> > > Available Radio Resource,
> > > Radio Resource Fluctation
> >
> >)
>
> **Spare Capacity Report Type**

Type of report profile = 1

Available Radio Resource

Percentage of reported average available sub channels and symbols resources per frame, 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. 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.

14.2.7.1.3.2 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.

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,
        BS List:
        BS_ID,
        Available Radio Resource,
        Radio Resource Fluctation,
        DCD Configuration Change Count,
        UCD Configuration Change Count
)

N NEIGHBORS

Number of neighbor BS's

BS_ID

Unique identifier of BS

Available Radio Resource

Percentage of reported average available sub channels and symbols resources per frame, 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. 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

14.2.7.1.3.3 C-RRM-IND (Event_Type == Spare Capacity Detailed Report)

Function:

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

Semantics of the service primitive:

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

The parameters in the attribute list are defined the same way as for the attribute list in "C-RRM-RSP (Operation Type ==Action, Action_Type==Spare Capacity Detailed Report)"

Change #4: Insert subchapter 14.2.7.1.3.4 C-RRM-IND (Event_Type == Neighbor-BS Permutation Zones Status Update) into 14.2.7.1.3

14.2.7.1.3.4 C-RRM-IND (Event_Type == Neighbor-BS Permutation Zones Status Update)
Sent from NCMS to BS.

Function:

This primitive can 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 Permutation Zones 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 Permutation Zone Radio Resource,
                                Permutation Zone Radio Resource Fluctuation,
                        DCD Configuration Change Count,
                        UCD Configuration Change Count
                )
```

N NEIGHBORS
   Number of neighbor BSs
BS_ID
   Unique identifier of BS
N_PERMUTATION_ZONES
   Number of Permutation Zones in total for DL and UL subframes at this BS.
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 Permutation Zone Radio Resource

Percentage of reported average available subchannels and symbols resources per permutation zone.

Permutation Zones Radio Resource Fluctuation

Permutation Zone Radio Resource Fluctuation is used to indicate the degree of fluctuation in DL or UL, resp., channel data traffic throughputs for the current Permutation Zone. Value range is the same as for "Radio Resource Fluctuation".

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