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Abstract	In this contribution, several primitives for Radio Resource Management are defined, as well as corresponding extensions of MAC management messages.
Purpose	Adoption
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Primitives for Radio Resource Management

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1 Introduction

WiMAX Forum Network Working Group (NWG) prepared a draft Stage-2 document on "WiMAX End-to-End Network Systems Architecture - Stage 2: Architecture Tenets, Reference Model and Reference Points" [1]. This also includes sections on Radio Resource Management (RRM): Functional Requirements, Functional Entities, Reference Model, Protocol and Procedures [2]. In particular, NWG proposed RRM primitives for information exchange between Base Stations (BS) or between a BS and a central component within a WiMAX network.

It is understood that the essential radio related parts of these RRM primitives shall be mapped into 802.16g [3]. So there is an overlap between the WMF NWG documents and 802.16g. This contribution aims at presenting the current status of the RRM protocol work in WiMAX Forum NWG to the IEEE 802.16g Working Group. Work on Stage-2 including RRM procedures is ongoing in WMF NWG, and feedback from 802.16g (NETMAN) is welcome. The authors are members of the RRM subteam in WMF NWG.

2 Current RRM concepts

RRM is defined as:
Measurement, *exchange*, and *control* of *radio resource-related indicators* (e.g. current subchannel allocations to service flows) in a wireless network.
> *Measurement* refers to determining values of standardized radio resource indicators that measure or assist in estimation of available radio resources.
> *Exchange* refers to procedures and primitives between functional entities used for requesting and reporting such measurements or estimations. The resulting information from exchange may be made available within the measuring station (using proprietary procedures and primitives), or, to a remote functional entity (using standardized procedures and primitives).
> *Control* refers to decisions made by the measuring station or remote entity to adjust (i.e. allocate, reallocate or deallocate) radio resources based on the reported measurements, other information, or using proprietary algorithms, and communicating such adjustments to network entities using standardized primitives. Such control may be local and remote from the measuring station

RRM procedures may provide *decision support* for one or more of the following WiMAX network functions. However, RRM specification shall not be tied to any one of these functions.
> **MS Admission Control** and **Connection Admission Control** – i.e. ascertaining a priori that required radio resources are available at a potential target BS before handover.
> **Service Flow Admission Control** – i.e. creation or modification of existing/additional service flows for an existing MS in the network.
> **Selection of values for Admitted and Active QoS parameter sets** for Service Flows.
> **Load Control** – manages situation where system load exceeds the threshold and some counter-measures have to be taken to get the system back to feasible load.

Handover preparation and Control – for improvement/maintenance of overall performance indicators (for example, RRM may assist in system load balancing by facilitating selection of the most suitable BS during a handover.)

According current NWG and 802.16g concepts, RRM is performed by help of two entities:
1) Radio Resource Agents (**RRA**), located in the BSs, and
2) One or more Radio Resource Controllers (**RRC**), located anywhere in the Network Control and Management System (**NCMS**).
RRM related communication can occur between
- RRA and RRC, and
- Among RRCs.

This communication is based on RRM primitives.

3 Primitives
Currently, the following RRM primitives have been specified

Name	Source	Destination	Purpose	Reporting or Decision support
RRM-PHY-parameters-request	RRC	RRA	Request for PHY-report, per MS.	Request reports from RRA
RRM-PHY-parameters-report	RRA	RRC	Assessment of link level quality per MS.	Reporting from RRA to RRC
RRM-Spare-capacity-report	RRA/RRC	RRC	Per-QoS profile capacity report per BS.	Request reports from RRA; Request reports from RRC
RRM-Spare-capacity-request	RRC	RRA/RRC	Request for spare capacity report per BS.	Reporting from RRA to RRC; Reporting between RRCs
RRM-Neighbor-BS radio resource status update	RRC	RRA	Update the broadcasted Neighbor BS list	Decision support

Table 1: Primitives for RRM

The first four are for measurement report from a BS to any other entity in the ASN; the fifth one is an example of "Decision Support": The RRM entity updates the neighbor BS list to be used by a Serving BS in Handover procedures.

4 Proposed Text Changes
Two changes to 802.16g are proposed:
      1) Modification to section 14.5.12 „Radio Resource Management";
      2) Addition of a new section 14.5.13.3 „BS Radio Resource Advertising"

14.5.12 Radio Resource Management

14.5.12.1 Radio Measurements and Reporting

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

14.5.12.1.1 RRM Primitives

14.5.12.1.1.1 RRM Spare Capacity Request Primitive
The Radio Resource Controller (RRC) may use this primitive to request a BS to provide spare capacity information to the RRC. Note that the RRC may be located in another BS, or in a central entity in the NCMS.

RRM Type
Indication of RRM type: Spare Capacity Request
Sender NCMS Node ID
NCMS Node or BS unique identifier
Target NCMS Node ID
NCMS Node or BS unique identifier
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

14.5.12.1.1.2 Spare capacity report primitive
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.

RRM Type
Indication of RRM type: Spare Capacity Report
Sender NCMS Node ID
NCMS Node or BS unique identifier

Target NCMS Node ID
    NCMS Node or BS unique identifier
Spare Capacity Report Type
    Type of report profile = 1
Available Radio Resource
    Percentage of reported average available subchannels and symbols resources per
    frame, as defined in section 14.5.13.3

14.5.12.1.1.3 PHY report request primitive

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.

RRM Type
    Indication of RRM type: Physical Parameters Request
Sender NCMS Node ID
    NCMS Node or BS unique identifier
Target NCMS Node ID
    BS unique identifier
MS ID
    48-bit unique identifier of the MS

14.5.12.1.1.4 RRM PHY report primitive

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).

RRM Type
    Indication of RRM type: Physical Parameters Report
Sender NCMS Node ID
    BS unique identifier
Target NCMS Node ID
    NCMS Node or BS unique identifier
MS ID
    48-bit unique identifier used by MS
Downlink Physical Service Level
    Channel rate available for the MS calculated as a multiple of 1/32 of nominal bandwidth in
    the correspondent direction assuming 1 bit/Hz. For example, if DL channel bandwidth is 10
    MHz, value PSL=4 means 4*1/32*10 Mbps = 1.25 Mbps. 1   PSL   96 (Number of 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 Physical Service Level
    Channel rate available for the MS calculated as a multiple of 1/32 of nominal bandwidth in the correspondent direction assuming 1 bit/Hz. (see definition of Downlink Physical Service Level)
Uplink RSSI mean
    As specified in 8.1.9 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].

14.5.12.1.1.5 RRM Neighbor-BS Radio Resource Status Update primitive
This primitive can be used by RRC to inform a Serving BS about the list of Neighbor BS's which are potential HO Target Base Stations for any MS's being served by the SBS, including an information about their radio resource status

RRM Type
    Indication of RRM type: Neighbor-BS Radio Resource Status Update
Sender NCMS Node ID
    NCMS Node or BS unique identifier
Target NCMS Node ID
    BS unique identifier
N NEIGHBORS
    Number of neighbor BS's
For (j=0; j<N NEIGHBORS; j++) {
    BS Identity
        Unique identifier of BS
    Available Radio Resource
        Percentage of reported average available subchannels and symbols resources per frame, as defined in section 14.5.13.3
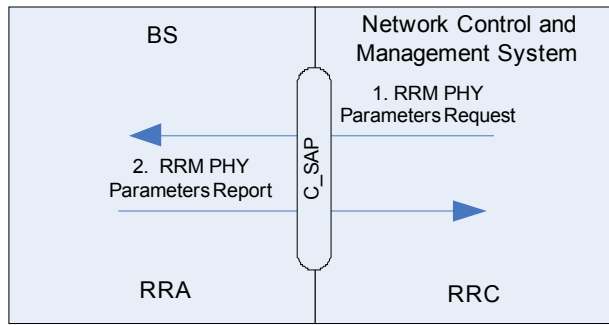   **DCD Configuration Change Count**
        This represents the Neighbor BS current Downlink Channel Descriptor (DCD) configuration change count
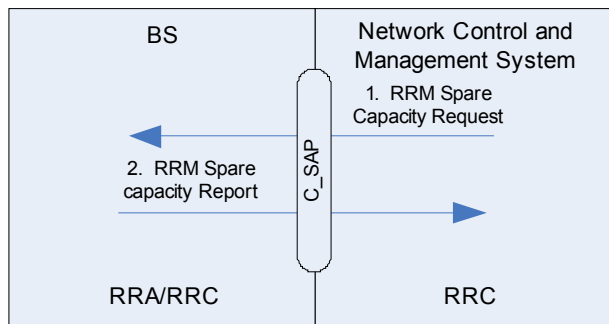   **UCD Configuration Change Count**
        This represents the Neighbor BS current Uplink Channel Descriptor (UCD) configuration change count
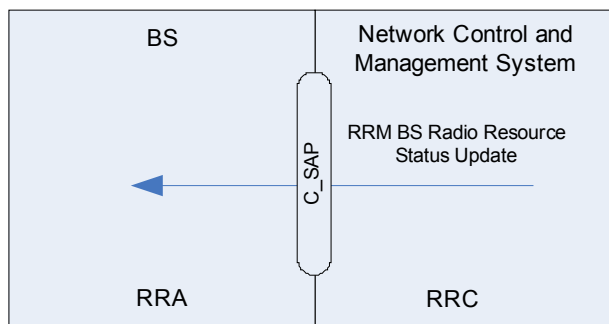**}**

14.5.12.1.2 RRM Procedures

Figure 1: Example Primitive Flow of Physical Parameter Report

Figure 2: Example Primitive Flow of Spare capacity Report

Figure 3: Example Primitive Flow of Radio Resource Status Update

14.5.13.3 BS Radio Resource Advertising

*[Apply the following modification to table **108f**]*

Table 108f—MOB_NBR-ADV message format

Syntax	Size (bits)	Note
Skip-optional-fields bitmap	8	Bit [0]: if set to 1, omit Operator ID field Bit [1]: if set to 1, omit NBR BS ID field Bit [2]: if set to 1, omit HO process optimization field Bit [3]: if set to 1, omit QoS related fields <u>Bit [4]: if set to 1, omit 802.16g related fields</u> Bit [45]-[7]: reserved

*[Add the following entries in the table **108f**, immediately above the row „DCD Configuration Change Count"]*

Syntax	Size (bits)	Note
if (Skip-optional-fields-[4]=0) {		
Skip-802.16g-fields bitmap	8	Bit [0]: if set to 1, omit Radio Resource related fields Bit [1]-[7]: reserved
if (Skip-802.16g-fields-[0]=0) {		
DL Available Radio Resource	8	Percentage of available radio resource DL 0x00 : 0% 0x01 : 1%, …, 0x64 : 100% 0x65 – 0xFE : reserved, 0xFF indicates no information available
UL Available Radio Resource	8	Percentage of available radio resource UL 0x00 : 0% 0x01 : 1%, …, 0x64 : 100% 0x65 – 0xFE : reserved, 0xFF indicates no information available
}		
}		

*[Add the following text after table **108f**]*

DL/UL Available Radio Resource:
> Available Radio Resource indicator shall indicate the average percentage of available physical radio resources for DL/UL where averaging shall take place over a time interval which shall be defined by configuration. Available physical radio resources shall be defined as the set of subchannels and symbols within a radio frame, which are not used by any non-best-effort service flow class.

5 References

[1]   WiMAX NWG Stage-2 specification, at WiMAX NWG Server under
        http://www.wimaxforum.org/apps/org/workgroup/nwg/document.php?document_id=1678

[2]   Radio Resource Management (RRM) text for WiMAX NWG Stage 2 specification;
        http://www.wimaxforum.org/apps/org/workgroup/nwg/document.php?document_id=1572

[3]   IEEE 802.16g baseline document 802.16g-04/03r2,
        http://ieee802.org/16/netman/docs/80216g-04_03r2.pdf

[4]   IEEE 802.16g Protocol Architecture Model.
        http://www.wirelessman.org/netman/contrib/C80216g-05_010r1.pdf