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Re:	Call for comments	
Abstract	This contribution is to inform the NetMan Task Group on the specification development work taking place in the WiMAX™ Forum Network Working Group (NWG).	
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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

According [1], the network side of the WiMAX network includes
- one or more Access Service Networks (**ASN**), and
- one or more Connectivity Service Networks (CSN)

The **ASN** includes
- a number of Base Stations (**BS**), and
- an ASN Gateway (**ASN GW**).

Radio Resource Management is understood as a function of the ASN which is performed by the Base Stations with our without support by a central Resource Manager function in the ASN GW.

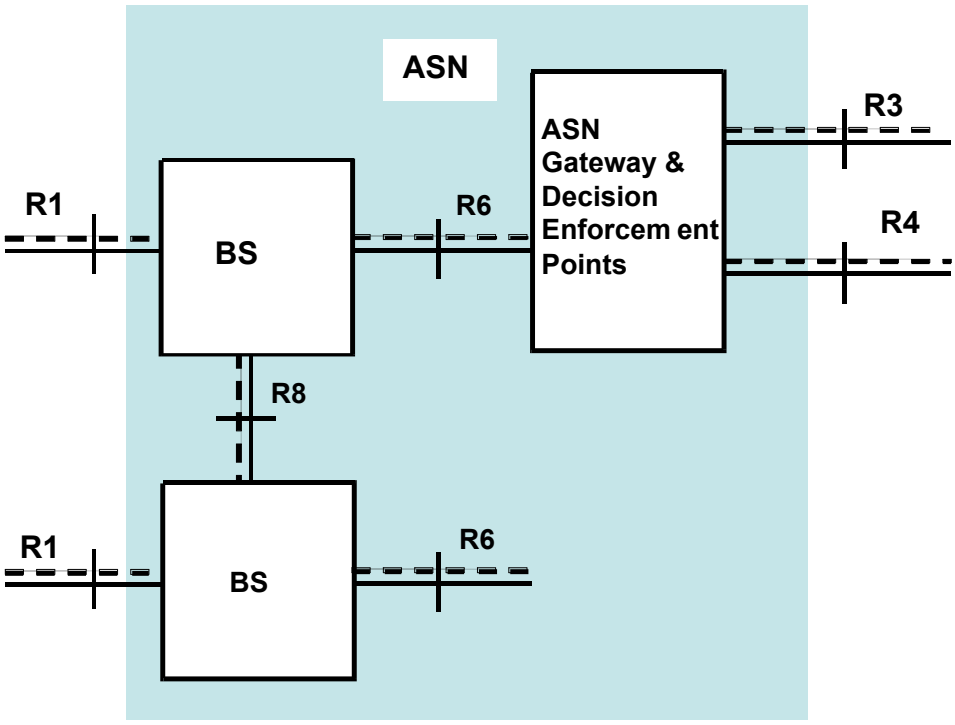


Figure 1: ASN Reference Model (from [1]).

RRM is defined in [1] and [2] 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 concept, RRM is performed by help of two entities in the ASN:
1) Radio Resource Agents (**RRA**), located in the BSs, and
2) one or more Radio Resource Controllers (**RRC**), located anywhere in the ASN, e.g. in the ASN GW, or collocated with a BS.

For the function split between RRA and RRC see [1] or [2]. 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 in [1] and [2]:

Name	Source	Destination	Purpose	Reporting or Decision support
RRM-PHY-parameters-request	RRC	RRA	Request for PHY-report, per MS.	Reporting from RRA to RRC
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.	Reporting from RRA to RRC; Reporting between RRCs
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 Advertising reconfiguration	RRC	RRA	Update the broadcasted Neighbor BS list	Decision support

Table 1: Primitives for RRM (from [1] and [2]).

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.

In addition, another RRM primitive has been specified in [1] and [2] although not fully made explicit:

Name	Source	Destination	Purpose	Reporting or Decision support
RRM-Service-Indicator-Definition	RRC	RRA	Request for PHY-report, per MS.	Reporting from RRA to RRC

Table 1: Service Indicator Definition Primitive (mentioned implicitly in [1] and [2]).

These primitives are presented below, including a draft version of the “RRM Service Indicator Definition primitive” which is under construction in the WMF NWG documents. - “Neighbor BS Advertising reconfiguration” is not shown since this is likely to be adopted from handover primitives.

The following tentative proposed changes should show the impact to 802.16g once the changes are approved.

4 Proposed Text Changes (currently for information only)

[*Modify section 14.5.12 as follow*]

14.5.12 Radio Resource Management

14.5.12.1 Radio Measurements and Reporting

The HO Control Primitives are a set of primitives for supporting HO procedure between BS and NCMS. They are defined for access to the Mobility Control entity to support handovers.

14.5.12.1.1 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.

Table 14.5.12.1.1: RRM Spare Capacity Request Primitive

Field	Size	Notes
Global Primitive Header	104 bits	Refer to Global Primitive Header (Global Primitive Header for 802.16g NCMS primitives)
QoS Profile Description Type	8 bits	Identifier for format description 0 : 3 or more services per MS 1-255 : reserved for future use
If (QoS Profile Description Type == 0) {		
NRTSInd	8 bits	Index for non real time service
RTSInd1	8 bits	Index for first real time service
RTSInd2	8 bits	Index for second real time service
}		
Report Characteristics	8 bits	0 : Completion of network entry 1 : Deregistration of MS 2 : Adding / changing / deleting connections 3 : MOB_MSHO-REQ received from MS 4 : MOB_SCAN-REPORT received from MS 5 : Association performed by MS 6 : MOB_HO-IND received by Serving BS 7 : Completion of network re-entry at Target BS after HO 8 : Report solicitation from ASN GW (RRC) 9-255 : reserved for future use

14.5.12.1.2 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. This Spare Capacity Report Primitive exists in two types: Type 1 for reporting a range of Spare Capacity Indicators (SCI) for a range of Physical Service Level (PSL) values, and Type 2 for reporting a single SCI associated to a single pair of UL PSL and DL PSL.

Type 1 is for reporting a range of Spare Capacity Indicators (SCI) for a range of Physical Service Level (PSL) values.

Table 14.5.12.1.2a: RRM Spare Capacity Report Primitive, Type 1

Field	**Size**	**Notes**
Global Primitive Header	104 bits	Refer to Global Primitive Header
QoS Profile Description Type	8 bits	Identifier for format description 0 : 3 or more services per MS 1-255 : reserved for future use
If (Description Type == 0) {		
NRTSInd	8 bits	Index for non real time service
RTSInd1	8 bits	Index for first real time service
RTSInd2	8 bits	Index for second real time service
}		
Num Records	8 bits	
For (j=0; j<Num Records; j++) {		
For (k=0; k<Num Records; k++) {		
SCI	16 bits	Spare Capacity Indicator SCI = 0 : no information available SCI > 32 : BS is able to accommodate (SCI – 32) MS's with QoS requirements specified by QoS profile descriptor and specific DL/UL PSL SCI < 32 : the BS suffers from degradation, which will be relaxed if (32 – SCI) MS's with corresponding PSL values leave the BS
}		
}		

Type 2 is for reporting a single SCI associated to a single pair of UL PSL and DL PSL.

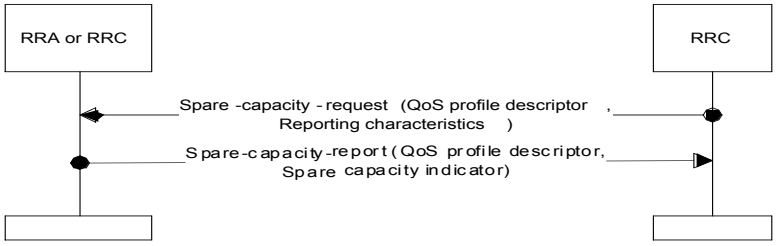
Table 14.5.12.1.2b: RRM Spare Capacity Report Primitive, Type 2

Field	Size	Notes
Global Primitive Header	104 bits	Refer to Global Primitive Header
QoS Profile Description Type	8 bits	Identifier for format description 0 : 3 or more services per MS 1-255 : reserved for future use
If (Description Type == 0) {		
NRTSInd	8 bits	Index for non real time service
RTSInd1	8 bits	Index for first real time service
RTSInd2	8 bits	Index for second real time service
}		

DL PSL	8 bits	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)
UL PSL	8 bits	Uplink Physical service level
SCI	16 bits	Spare Capacity Indicator SCI = 0 : no information available SCI > 32 : BS is able to accommodate (SCI – 32) MS's with QoS requirements specified by QoS profile descriptor and specific DL/UL PSL SCI < 32 : the BS suffers from degradation, which will be relaxed if (32 – SCI) MS's with corresponding PSL values leave the BS

The following figure shows an elementary procedure including Spare capacity Request and Response.

Figure 14.5.12.1.2: Spare Capacity Request and Response Procedure



14.5.12.1.3 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.

Table 14.5.12.1.3: RRM PHY report request primitive

Field	Size	Notes
Global Primitive Header	104 bits	Refer to Global Primitive Header
MS-Node-ID	48 bits	Unique identifier of MS

14.5.12.1.4 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).

Table 14.5.12.1.4: RRM PHY report primitive

Field	Size	Notes
Global Primitive Header	104 bits	Refer to Global Primitive Header
MS-Node-ID	48 bits	Unique identifier of MS
DL PSL	8 bits	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)
DL RSSI mean	8 bits	As specified in 8.1.9 Channel quality measurements [802.16-2004]
DL RSSI standard deviation	8 bits	As specified in 8.1.9 Channel quality measurements [802.16-2004]
DL CINR mean	8 bits	As specified in 8.1.9 Channel quality measurements [802.16-2004]
DL CINR standard deviation	8 bits	As specified in 8.1.9 Channel quality measurements [802.16-2004]
UL PSL	8 bits	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. For example, if UL 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)
UL RSSI mean	8 bits	As specified in 8.1.9 Channel quality measurements [802.16-2004]
UL RSSI standard deviation	8 bits	As specified in 8.1.9 Channel quality measurements [802.16-2004]
UL CINR mean	8 bits	As specified in 8.1.9 Channel quality measurements [802.16-2004]
UL CINR standard deviation	8 bits	As specified in 8.1.9 Channel quality measurements [802.16-2004]

14.5.12.1.5 RRM Service Indicator Definition primitive

The Radio Resource Controller (RRC) may use this primitive to inform a BS about an association of a **Service Indicator (ServInd)** value to a specific service type which is characterized by certain QoS parameters. The purpose of such association is to have these ServInd values available for subsequent usage of RRM Spare Capacity Request and RRM Spare Capacity Report Primitive which include the parameters NRTSInd, RTSInd1, and RTSInd2: For each of these parameters a ServInd value can be included, representing a pointer to the ServInd table which has been established by means of the RRM Service Indicator Definition primitive.

With each application of this RRM Service Indicator Definition primitive, one such association of NRTSInd or RTSInd is defined or redefined in the BS.
- For definition of a value of NRTSInd, the “Service Type” parameter in this primitive is set to 0 (nrtPS);
- For definition of a value of RTSInd which can be used as RTSInd1 or RTSInd2 in the Spare Capacity Request/Report primitives, the “Service Type” parameter in this primitive is set to 1 (rtPS or exrtPS) or 2 (UGS).

Table 14.5.12.1.5: RRM Service Indicator Definition primitive

Field	Size	Notes
Global Primitive Header	104 bits	Refer to Global Primitive Header
ServInd	8 bits	Unique identifier of QoS profile
Service Type	8 bits	0 : nrtPS 1 : rtPS or exrtPS 2 : UGS
If (Service Type == 0) {		
DL Minimum reserved traffic rate	32 bits	bits per second as specified in 802.16-2004 11.13.8
DL maximum Sustained Traffic rate	32 bits	bits per second as specified in 802.16-2004 11.13.8
DL Traffic Priority	8 bits	0-7 as specified in 802.16-2004 11.13.5
DL Request/Transmission Policy	32 bits	as specified in 802.16-2004 11.13.12
UL Minimum reserved traffic rate	32 bits	bits per second as specified in 802.16-2004 11.13.8
UL maximum Sustained Traffic rate	32 bits	bits per second as specified in 802.16-2004 11.13.8
UL Traffic Priority	8 bits	0-7 as specified in 802.16-2004 11.13.5
UL Request/Transmission Policy	32 bits	as specified in 802.16-2004 11.13.12
}else if (Service Type == 1){		
DL Maximum Latency	32 bits	ms as specified in 802.16-2004 11.13.14
DL Minimum Reserved Rate	32 bits	bits per second as specified in 802.16-2004 11.13.8
DL Maximum Sustained Rate	32 bits	bits per second as specified in 802.16-2004 11.13.8
DL Traffic Priority	8 bits	0-7 as specified in 802.16-2004 11.13.5
DL Request/Transmission Policy	32 bits	as specified in 802.16-2004 11.13.12
DL Unsolicited Polling Interval	16 bits	ms as specified in 802.16-2004 11.13.30
UL Maximum Latency	32 bits	ms as specified in 802.16-2004 11.13.14
UL Minimum Reserved Rate	32 bits	bits per second as specified in 802.16-2004 11.13.8
UL Maximum Sustained Rate	32 bits	bits per second as specified in 802.16-2004 11.13.8
UL Traffic Priority	8 bits	0-7 as specified in 802.16-2004 11.13.5
UL Request/Transmission Policy	32 bits	as specified in 802.16-2004 11.13.12
UL Unsolicited Polling Interval	16 bits	ms as specified in 802.16-2004 11.13.30
}else if (Service Type == 2){		
Tolerated jitter	32 bits	ms as specified in 802.16-2004 11.13.13
SDU size	8 bits	In bytes as specified in 802.16-2004 11.13.16
Minimum Reserved Rate	32 bits	bits per second as specified in 802.16-2004 11.13.8
Maximum Latency	32 bits	ms as specified in 802.16-2004 11.13.14
Request/Transmission Policy	32 bits	as specified in 802.16-2004 11.13.12
Unsolicited Grant Interval	16 bits	ms as specified in 802.16-2004 11.13.29
}		

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