Project	**IEEE 802.16 Broadband Wireless Access Working Group** <http://ieee802.org/16>
Title	**DL/UL Resource Allocation for Improved Intra-system Coexistence**
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Source(s)	Ranga Reddy US Army E-mail: Ranga.Reddy@us.army.mil Apurva Mody BAE Systems E-mail: apurva.mody@baesystems.com
Re:	IEEE 80216m-08/005 Call for Contributions, Ballot ID "tgmsdd"
Abstract	This contribution covers a resource allocation scheme that can help avoid cell-edge interference and improve performance regarding intra-system coexistence.
Purpose	Review contribution and consider adoption of recommendations in text for 802.16m SDD
Notice	
Release	
Patent Policy	

DL/UL Resource Allocation for Improved Intra-system coexistence

Ranga Reddy
US Army

Apurva Mody
BAE Systems

1. Introduction

Sub-clause 6.4, "Radio Resource Management" [1], requires definition of efficient reporting, monitoring, & resource management techniques that will have to be met in order to support efficient utilization of system resources and to reduce interference. Sub-clause 8.3, "Co-deployment with other networks" [1], requires definition of methods to avoid being the victim or source of interference when co-deployed with legacy non-IEEE 802 (3GPP, CDMA2000, TD-SCDMA, etc.) and IEEE 802-based systems (802.16, 802.15, 802.11, 802.22, etc).

In order to meet these requirements, solutions to handle interference and ensure efficient utilization of resources between 802.16m systems must first be defined. This contribution seeks to address the topics "Downlink Control Sturctures" and "Downlink Physical Resource Allocation Unit (Resource Blocks & Symbol Structures)" solicited in [2].

2. Proposed Solution

2.1 Solution Overview

This contribution proposes a couple of changes to both the PHY and MAC. Section 2.2 of this contribution covers proposed changes to the PHY, and section 2.3 of this contribution covers proposed changes to the MAC. The solution proposed in this contribution assumes (but is not limited to) a single frequency/channel system deployment and that a deployment-wide, common antenna sectorization pattern is used.

2.1.1 PHY Proposed Changes Overview

The proposed changes to the PHY consist of:

1. Adding information to the super-frame control header (SCH) to allow
   a. scheduling of multiple "Resource Allocation Decision Periods" to be interspersed between radio frames in a super-frame
   b. define dedicated (or configurable) sub-channels for handling coexistence, mobility/HO, reporting & synchronization
2. Break up cell into sectors. These can be physical sectors based on the number of sectors used for

a sectorized antenna, or logical sectors if an omni-directional antenna is used
3. Define resource allocation block as a sub-channel + sector tuple. An example of the frame structure definition that can be used to support this is outlined in [3] & [4].
4. Each BS allocates resource blocks on a per sector basis.
5. For the coexistence sub-channel, define message (coexistence information) that carries the BSID, location, sub-channel permutation/sector, schedule for rotation of sub-channel permutation configuration for each sector that is transmitted on it.

2.1.2. MAC Proposed Changes Overview

The proposed changes to the MAC consist of:

1. Allow BS to periodically exchange coexistence information utilizing the backhaul, and via a broadcast to SSs in its own cell using a dedicated sub-channel.
2. Cell-edge SSs may overhear the coexistence information broadcast from neighboring cells and may be permitted to relay this information, as heard from another cell, to its own serving BS.
3. BS then uses the coexistence information received from other BSs, to determine if the current block allocations for other sector(s) in neighboring cells (that border the sectors of its cell), overlap with block allocations in its own cell. Resource allocation decisions are made at the end of the resource allocation decision period, and are enforced for the following radio frame. .
4. If there is overlap, then BSs will have to negotiate use of the portion of the block allocation in conflict. This negotiation would take place prior to the start of the Resource Allocation Decision Period that precedes the frame in which there will be a conflict. If there is no overlap, BS then can immediately allocate UL/DL resources to the SS in that sector.
5. Allow for shifting of resource block allocations in each sector of cell, to minimize contention and interference. This shifting is executed prior to a resource allocation decision.

2.2 Proposed PHY Changes

In section 2.1.1 of this contribution the proposed changes to the PHY are summarized. This section provides more information on how the items in section 2.1.1 may be implemented.

2.2.1 Super-frame Control Header & Resource Allocation Decision Periods

Each BS constructs its own super-frame and configures the SCH. The SCH precedes the radio frames. In this concept, the SCH is used to signal two concepts.

1. The first concept is the Resource Allocation Decision Period (RADP). The RADP is defined as a period after each radio frame, during which radio resource allocation decisions are made. In addition to signaling the existence of RADPs, the SCH will indicate how many there are and when they are scheduled in the super-frame. There can be 1, 2, 3, or 4 RADPs. Allowing for more RADPs, gives the system the capability to be more responsive to “perceived” levels of interference. Figure 1 illustrates an example of a super-frame configuration.

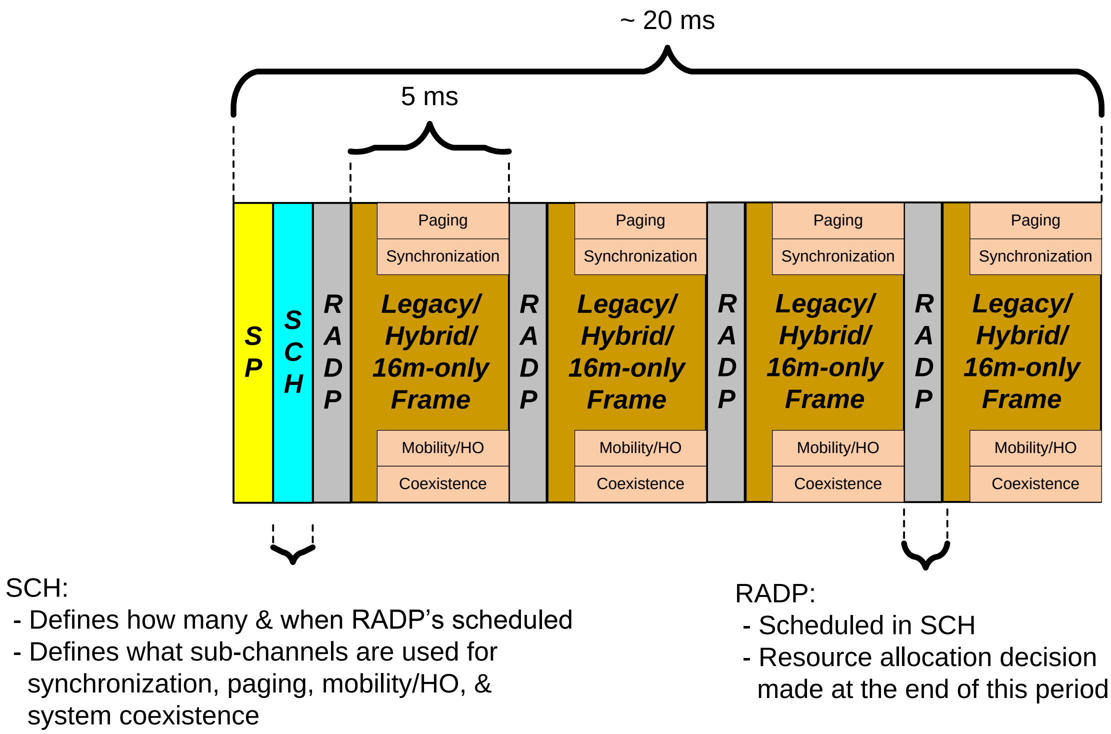

Figure 1 – Super-frame with Four Resource Allocation Decision Periods

2. Advertise a set of dedicated sub-channels that exist for mobility/HO, measurement/reporting, synchronization, & coexistence information (Section 2.2.3) exchange.

2.2.2 Cell Sectorization & Resource Allocation Block Definition

The process of breaking up cells into multiple sectors, e.g. sectorization, is a generally accepted method for increasing system capacity. With regard to this contribution, the sectorization provides a basis for defining the resource allocation block.

The resource allocation block is defined as a tuple of sub-channel (subset) per sector assignment. Upon initialization/startup of system, the BS will assign a subset of the sub-channel space to each sector.

This contribution does not propose a specific frame structure to signal resource allocation assignments. However, the method proposed in this contribution is complimentary with the frame structure as defined in contributions C80216m-08/038r1 [3] & C80216m-08/039 [4] that were submitted (but not presented) for IEEE 802.16 WG Interim Session #53 in Levi, Finland (20-25 January 2008).

2.2.3 Coexistence Information

The Coexistence Information (CI) contains BSID of the cell, BS GPS position, sub-channel set assignment / sector, configuration control (Section 2.3.3), and configuration shifting schedule (Section 2.3.3). Table 1 is a breakdown of the expected message size requirement by each field. Table 2 focuses on the configuration of the sub-channel set / sector assignment definition.

Item	Size (bits)	Description
BSID	48	BSID definition provided in reference system description
Position	64	Lat/Long/Alt definition provided in reference system description

Sub-Channel set / sector	Variable, 1 definition / sector	See Table 2
Configuration Shifting Control	8	0_x00 – Clockwise Shift 0_x01 – Counter-Clockwise Shift 0_xX2 – + Shift by amount defined by X 0_xX3 – - Shift by amount defined by X
Configuration Shifting Schedule	2	00 – every RADP 01 – Every 3rd RADP 10 – Every 2nd RADP 11 – Every 4th RADP

Table 1 – Expected Size Requirements for Items in Coexistence Information Message

Item	Size (bits)	Description
Sector ID	7	Unique ID to that sector in the cell
Section Orientation	9	Needed to determine sector boundaries (on cell edge) are. Units in degrees from reference of 0 (compass North), that denotes the "end" of sector space.
Start of sub-channel set	8	Sub-channel that denotes the start of the set allocated to this sector
# of sub-channels in set	8	# number of sub-channels in this set

Table 2 – Breakdown of Sub-channel Set / Sector Definition and Item Size Requirement

So, for the three sector cells described in Figures 2 - 5, approximately 218 bits would be required to transmit CI.

2.3 Proposed MAC Changes

2.3.1 Transmission of Coexistence Information

CI is periodically emitted by the BSs or relayed by SSs. This concept does not propose a management message format. However, we do assume that message format will be similar to the format described in Table 1 and 2.

2.3.2 Resource Allocation Decision During Resource Allocation Decision Period

As defined in Section 2.3.1, BSs can collect CI in either of two ways. The BS uses the CI that is collected, and uses it to build a local database of resource block allocation (sub-channel set / sector) configurations from neighboring cells.

By using the information in the local database, the BS can determine how it may be limited in its ability to actually allocate resources for SS in each of the sectors in its own cell. By comparing a the resource block allocation in a given sector to that of the configuration associated with sector(s) in other cells that "border" the sector of interest, the BS determines if there is an overlap or partial/full overlap.

If there is no overlap for a sector's resource block allocation, then the BS can immediately allocate those resources for the SSs in that sector. If there is overlap, then there are a couple of options that can be pursued:

1. The BS can directly contend for the sub-channels that are directly overlapping.
2. The BS can request temporary usage of the sub-channels in conflict.

The definitions of the messages and signaling required to support these options are not defined by this contribution. The resource allocation decision is broadcast during the RADP, and is applicable to the radio frame(s) that immediately follow it.

2.3.3 Shifting of Resource Allocation Block Configuration

The concept of shifting the resource allocation block configuration is introduced here as a method to reduce the chances there will be overlap in configurations, thereby avoiding the overhead of implementing one of recommendations for mitigating overlap stated in Section 2.3.2.

Initially each BS allocates sub-channel sets to each of its sectors. During the next RADP, the BS "moves" this configuration to the next sector in one of two ways. The first way is to take the resource block allocation for a given sector and set up the next sector, moving clock-/counter-clockwise, with that configuration. The second way is to apply an additive or subtractive shift to the range of sub-channels for each sector. Regardless of the method employed, the shift in configuration is executed prior to any determination of overlap in sector configurations.

Figures 2 & 3 illustrate the counter-clockwise shift. Figure 2 is an example of a starting point, where there is overlap discovered in one RADP by various cells for different group of sectors. Figure 3 represents the clockwise shift executed prior to the decision made during the next RADP (if shifting scheduled to happen every RADP).

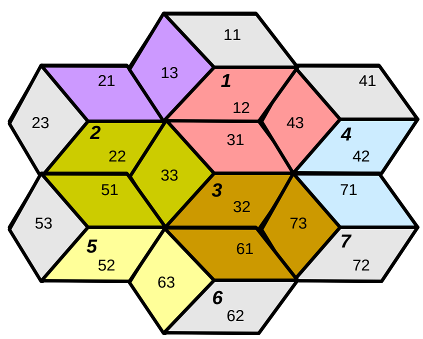

Figure 2 – Overlap Detected In Sectors That Border Each Other

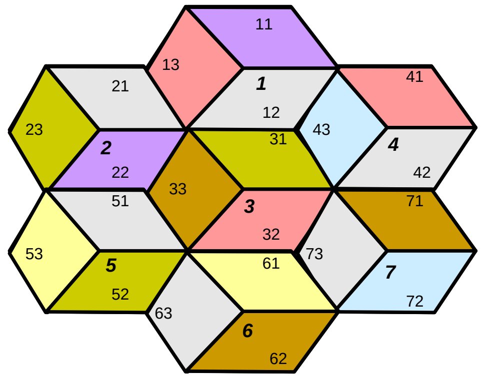

Figure 3 – No Overlap After Counter-clockwise Shift

Figure 4 is the frame structure analog for the DL portion of the frame [4] of the initial state described in Figure 2. The colored green bars border sectors from BS 2, 3, & 5 that border each other. Figure 5 demonstrates BS 2 utilizing a -10 shift, BS 3 utilizing a +10 shift, and BS 5 utilizing a +20 shift.

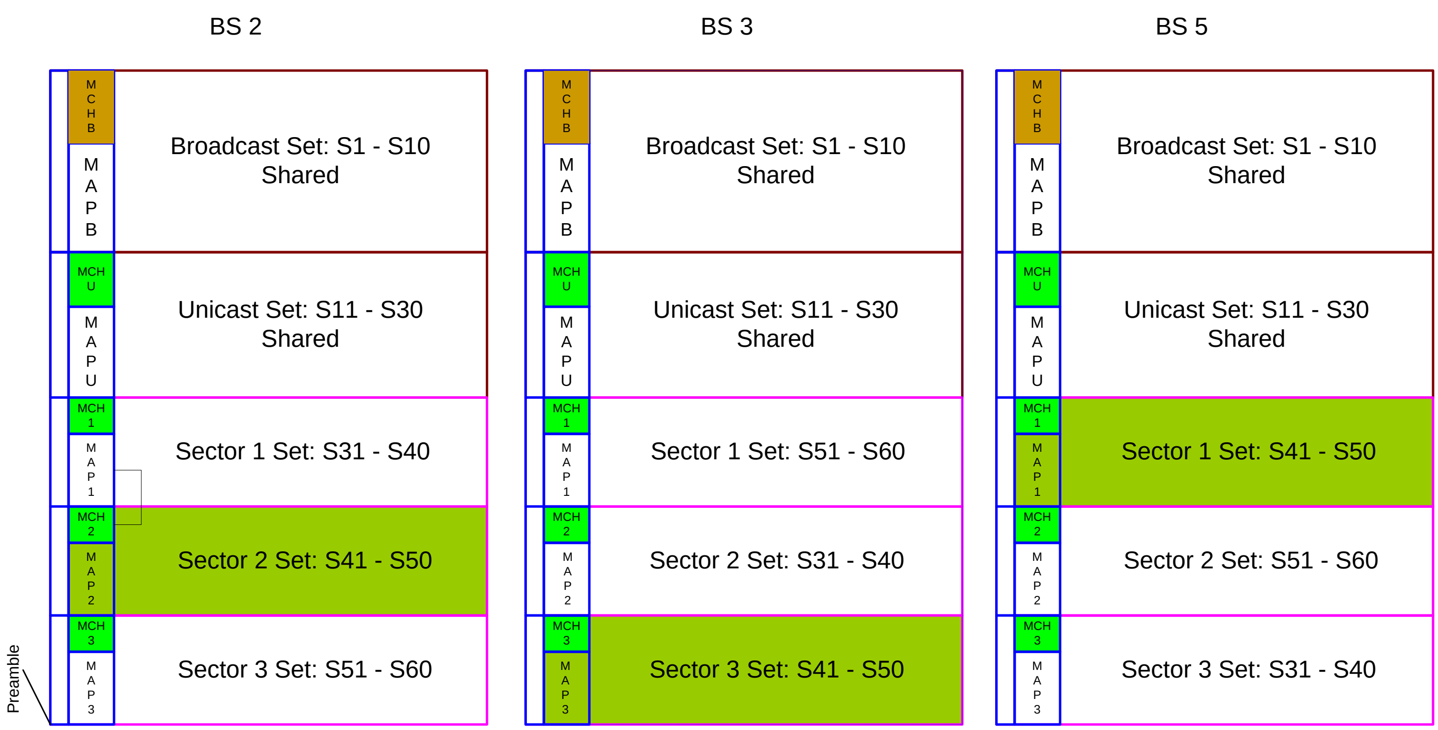

Figure 4 – DL Frame version of Figure 2

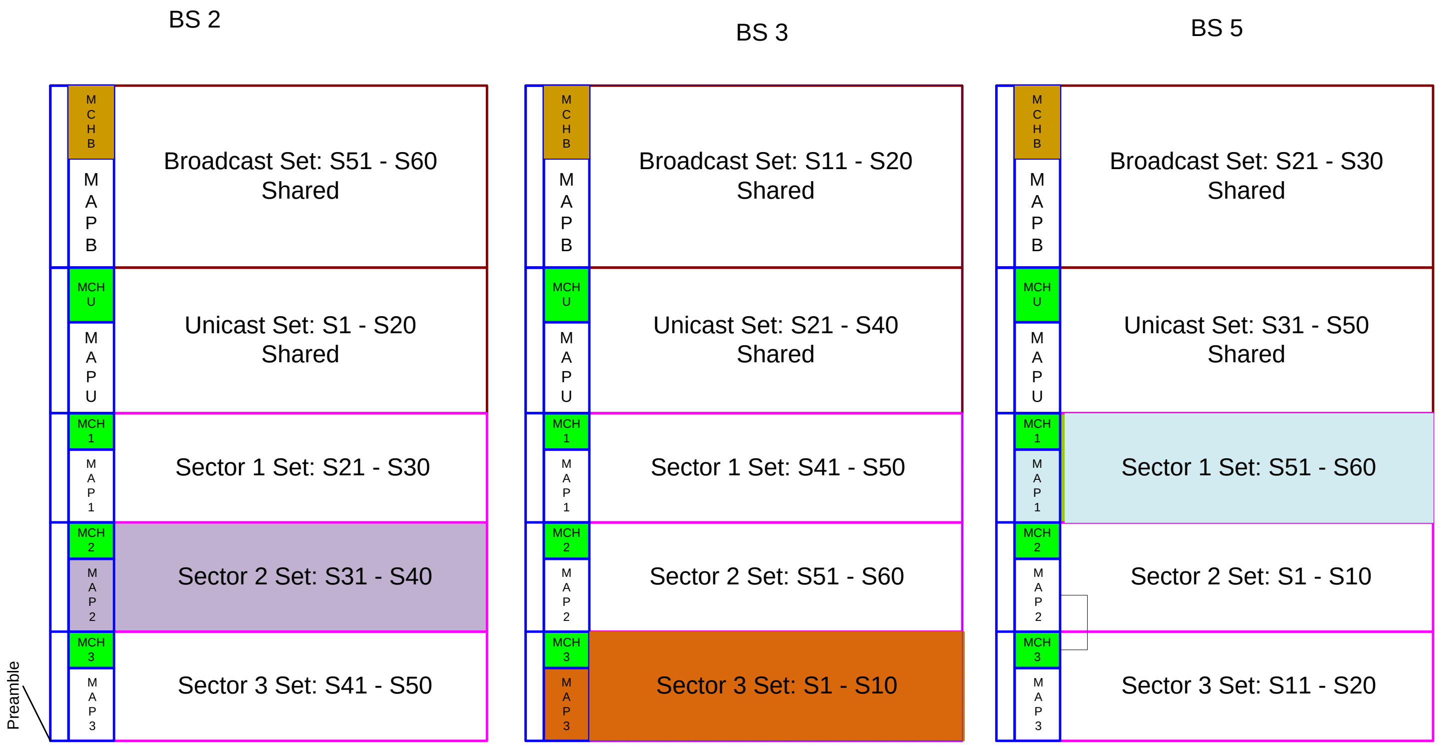

Figure 5 – DL Frame configuration after shifting

Including position information, resource allocation block configuration, configuration shifting control, and configuration shifting schedule for each BS in the coexistence information, allows a BS to make reasonable (1st order) estimations on what level of interference will exist at the cell edge (for each sector) for some time into the future. When overlap in resource block allocation configurations is expected, BSs can prepare for it by implementing one of the methods described in Section 2.3.2.

3 Proposed Text Changes for SDD

1. Accept text in Section 2 of this contribution for SDD
2. Consider text recommendations in contributions [3] & [4] for acceptance into SDD.

4 References

[1] Cudak, Mark, "IEEE 802.16m System Requirements", document IEEE 80216m-08/002r4, October 2007
[2] "Call for Contributions on Project 802.16m System Description Document (SDD)", document IEEE 80216m-08/005, January 2008.
[3] Goldhammer, Marianna, "Zones and more details on the 802.16m frame structure for improved intra-system coexistence", contribution IEEE C80216m-08/38r1, January 2008.
[4] Goldhammer, Marianna, "802.16m basic frame structure for improved intra-system coexistence", contribution IEEE C80216m-08/39, January 2008.