Project	**IEEE 802.16 Broadband Wireless Access Working Group** <http://ieee802.org/16>
Title	**Relay Frequency Reuse Scheme**
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Re:	SDD Change Request
Abstract	This contribution specifies Relay Frequency Reuse scheme
Purpose	For consideration and adoption into the 16m SDD document.
Notice	
Release	
Patent Policy	

Relay Frequency Reuse scheme

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Relay Frequency Reuse scheme

Introduction

The latest version of the IEEE802.16m SDD [1] specifies a Fractional Frequency Reuse (FFR) technique between different sectors of the cell and Inter-ABS Coordination in order to control the level of interference and optimize the reuse of frequency resources in the deployment. The SDD also specifies support of ARS in the cell sector. However, no mechanism is specified to control interference level and reuse of frequency resources within relay-enabled sector.

This contribution proposes a frequency reuse scheme that can be used by the ABS and ARSs within a sector. We use the term Relay Frequency Reuse (RFR) to describe this scheme.

Motivation

When several ARSs are used in the same sector, operating simultaneously in the same frequency resources, additional cell edges are formed within the sector. Allowing the ABS and ARSs to operate simultaneously on the same frequency increases the degree of frequency reuse and thus increases system capacity, but the AMSs located at the cell edges between the ARSs and ABS experience interference from the stations within the sector. This problem can be solved by applying the RFR scheme between the ABS and ARSs to enable different levels of frequency reuse between the access stations in the sector.

In accordance with the RFR scheme the communications within the sector may be arranged in several ways:

- Several access stations within the sector (ABS and/or ARSs) may share the time-frequency resources to serve different AMSs simultaneously thus taking advantage of high frequency reuse factor between stations.
- Access stations may communicate with their associated AMSs in different time-frequency resources thus taking advantage of reduced interference level between the stations within the sector.

To enable the RFR in the 802.16m frame structure it is proposed to implement RFR partitions in the frequency domain, each partition for use by one or more access stations. Note that an access station uses more than one partition to communicate with different AMSs. For example, the ABS may serve AMSs located close to it in an RFR partition exploited by the ABS and several ARSs simultaneously, and the ABS may communicate with another AMS located far it in an RFR partition used only by the ABS to arrange interference-free communication session.

The assignment of access stations to specific RFR partitions and setting partitions' sizes and their locations in the frequency band may be performed in an adaptive way taking into account factors such as traffic load at the access stations, link qualities between access stations and the associated AMSs in different RFR partitions, reuse factors and the interference levels.

It should be noted that the RFR approach may be used together with FFR (fractional frequency reuse) to achieve further system performance improvement.

Simulation Results

We illustrate the utility of RFR by providing an example scenario where RFR can be used to improve performance. Simulation results are obtained using an SLS with the relay functionality, as specified in the EMD [2]. We analyze the scenario in which the RSs do not have enough throughput to use all of the resources in their access zone. Such a scenario can occur because the BS must configure the frame in order to provide sufficient space in its DL Transmit zone for relay link transmissions. Also, zone configuration is performed on a sub-frame granularity, which is fairly coarse (a subframe is 6 symbols). For analysis we use the scenario with two ART (above roof-top) ARS. Channels were considered to be slowly-varying over time (3 km/h AMS speed). 20 AMSs were served in each sector with help of PF scheduling algorithm. Open loop MIMO and DRU permutation on the DL were used. The frame was composed of the 4 DL subframes (6 symbols each), at the ABS 2 of them were assigned to the 16m DL access zone, and 2 to the 16m DL Transmit Zone. The ARS frame structure was configured using the same 2:2 split. We utilized distributed scheduling using the proportional fair scheduler as specified in the EMD.

In order to model the situation in which the ARSs do not have enough data to fill their access zone, we limited the amount of resources available to the ARS to a given percentage. In the simulations we used values of 40% and 60% for the RS load. We then ran simulations using RFR to constrain the ARS transmissions to a known (and coordinated) frequency partition and allowing the ARSs to schedule transmissions anywhere in the zone. We also show results for the case without relay for reference.

Table 1 shows the performance metrics for different relay frequency reuse partitioning scenarios, including:

1. ABS only

Reference scenario, with no ARSs deployed.

2. No interference control 40% Load on RSs

In this scenario, RFR partitions are not used. ARSs are limited to using only 40% of the access zone resources, but may place its allocations anywhere in the access zone. There is no interference control between the BS and RS or between the sectors.

3. Intra-cell interference control; 40% Load on RSs

In this scenario RFR partitions are used. Two frequency partitions are created in the access zone. One occupies 40% of the subchannels. Both ARS and ABS transmit in this partition. The ARSs do not transmit in the second frequency partition (which occupies 60% of the subchannels). This second partition is used by the ABS to transmit to MSs without interference from the RS in its sector.

4. No interference control 60% Load on RSs

In this scenario, RFR partitions are not used. ARS are limited to using only 60% of the access zone resources, but may place its allocations anywhere in the access zone. There is no interference control between the BS and RS or between the sectors.

5. Intra-cell interference control; 60% Load on RSs

In this scenario RFR partitions are used. Two frequency partitions are created. One occupies 60% of the subchannels. Both ARS and ABS transmit in this partition. The ARSs do not transmit in the second frequency partition (which occupies 40% of the subchannels). This second partition is used by the ABS to transmit to MSs without interference from the RS in its sector.

Simulation results for all mentioned scenarios are shown in Table 1.

Table 1 Performance analysis of the RFR technique

#	Scenario	Aggr.sector throughput (Mbps)	ABS/ARS throughput (Mbps)	Cell edge user throughput (Mbps) (normalized to 10 MS/sect)
1	ABS only	10.7 (0%)	10.7 / 0	0.129
2	ABS + 2 ARSs; 40% load No interference control	14.8 (+38.3%)	10.6 / 4.2	0.129
3	ABS + 2 ARSs; 40% load Intra-cell interference control	15.1 (+41.1%)	11.0 / 4.1	0.136
4	ABS + 2 ARSs; 60% load No interference control	15.6 (+45.8%)	9.6 / 6.0	0.156
5	ABS + 2 ARSs; 60% load Intra-cell interference control	16.0 (+49.5%)	10.0 / 6.0	0.165

It can be seen that RFR scheme gives the opportunity of flexible adaptation of the frequency reuse to ARS throughput requirements. Relays with RFR scheme give noticeable performance improvement in terms of aggregate sector and cell edge throughputs in comparison with the single ABS case. It should further be noted that further performance gains can be expected if RFR partitions are aligned across the sectors.

References

[1] IEEE 802.16m System Description Document (IEEE 802.16m-08/003r7)

[2] IEEE 802.16m Evaluation Methodology Document

Text Proposal

Insert the following text into section 15 of the SDD

15.4.x Relay Support for Interference Mitigation

15.4.x.1 Relay Frequency Reuse

15.4.x.1.1 RFR Frequency Partitions

When ARSs are used within a deployment, frequency partitions can be used to implement a Relay Frequency Reuse (RFR) scheme between the ABS and ARSs within a sector. RFR Frequency partitions can be created within the ABS and ARS frame. The ABS and ARSs within the sector can be assigned to transmit or be idle within each of the partitions, allowing different levels of reuse to be performed in different partitions. AMSs are assigned to be served in a given frequency partition or partitions based on interference measurements reported by the ARSs in a manner similar to DL and UL FFR as described in section 20.1. An example of frequency partition assignment for the sector with two ARSs is shown in Figure X. The assignments shown in the figure are provided for illustrative purposes. It is expected that in reality the partitions will not be symmetric in size because the ABS and ARSs will generally have different coverage areas and traffic load. It is also likely that not all of the partitions shown in the figure will be used.

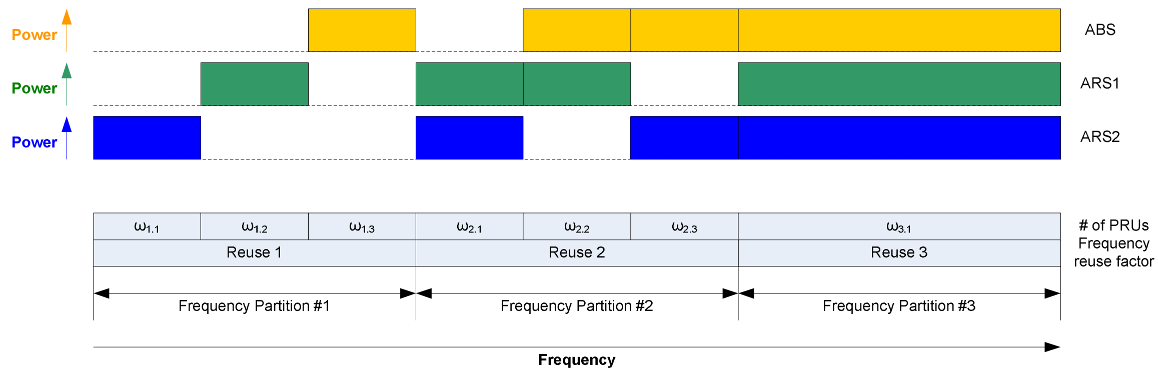

Figure X. Basic Concept of Relay Frequency Reuse

RFR and FFR can be used together by creating FFR partitions and assigning them across sectors and then further partitioning the frequencies assigned to a sector into RFR partitions.

15.4.x.1.2 Interference measurements and signaling support

The interference measurements and signaling support for RFR is the same as for FFR. Interference measurement and signaling support for the DL is described in section 20.1.1.1 and for the UL is described in section 20.1.2.1.