Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	Reuse 1 support for first PUSC zone
Date Submitted	**2005-06-23**
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Re:	IEEE P802.16-2004/Cor1-D3
Abstract	We propose a small correction to outer PUSC permutation base that will enable reuse 1 deployment.
Purpose	Adopt changes
Notice	
Release	
Patent Policy and Procedures	

Reuse 1 support for first PUSC zone

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1. Motivation

Although reuse 1 deployment is supported by different OFDMA zones (PUSC, FUSC, OFUSC), the outer permutation seed in the first zone prevents using this option. We propose a small correction that will enable reuse 1 deployment.

2. Details

2.1. General

As we'll discuss below, the standard supports both reuse 1 and reuse 3 deployments. Reuse 1 has the advantage of not requiring frequency planning. In a reuse 1 system there is a need for randomization of hits between subchannels on each cell/sector. This is supported in the standard by PUSC (with outer permutation seed = IDCELL), FUSC and OFUSC permutations. PUSC has two modes, one suitable for reuse 1 and one for reuse 3. However, currently PUSC in the first zone can be only activated in reuse 3 mode. Since the FCH maps are in the first zone, this forces frequency planning in the system in order for SS to be able to register and obtain map information, so it is impossible to deploy a reuse 1 system, in spite of existing support in this mode in other zones (except the first). The solution to this problem is straightforward and simple, by enabling to optionally set the outer permutation seed to IDCELL in the first zone. This solution doesn't remove any deployment option that currently exists.

2.2. Reuse 1 and reuse 3

The 802.16 standard has two basic reuse patterns to supply system coverage in a single frequency deployment:

> Reuse 3 - in which 3 orthogonal sets of subchannels are used (facilitated by the segment index 0,1,2), and each BS/sector in the system is allocated one of the 3 segments. This kind of deployment requires 3-color frequency planning (replacing frequency with segment).
> Reuse 1 – in this deployment no frequency planning is required. All cells use similar configuration except for different IDCELLs (similar to CDMA system).

The advantages of reuse 1 is more flexible planning of the system, especially when it is not homogenous (different number of sectors in each cell), and dynamic (addition of cells).

2.3. SIR requirements in reuse 1 system (downlink)

In a reuse 1 systems since there is no planning the SS suffers from interference from all adjacent cells/sectors. As a result the average SINR is negative in large parts of the system (depending on exact deployment). The figure below shows the SINR distribution in a typical cell in a hexagonal 3 sector deployment. About 30% of the SS have average SNR below 0dB.

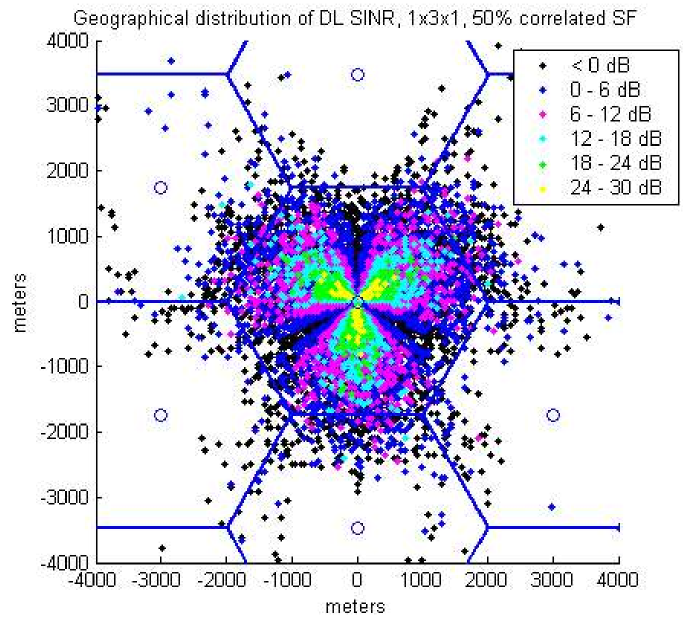

Figure 2.2.1: Geographical distribution of SINR
(single frequency deployment, 3 sector cells,
50% correlated shadow fading with ^{2}=8.9dB)

When the average SINR is negative the instantaneous SINR can be much lower part of the time. Note that flat fading occurs both for the serving BS signal and for the interferers, so part of the time the target signal will be momentarily faded, while the interferers are momentarily amplified.

In order to be able to demodulate the downlink data the modulation should be robust enough to demodulate signals suffering from high interference levels. This is facilitated by mechanisms to reduce the MCS levels and to de-correlate the transmissions of the serving BS signal from the interferers, which can generally be regarded as processing gain.

In order to get an idea of how much processing gain is required, a simple simulation of one interferer with fast fading in a fully-loaded system using QPSK 1/2 CC coding:

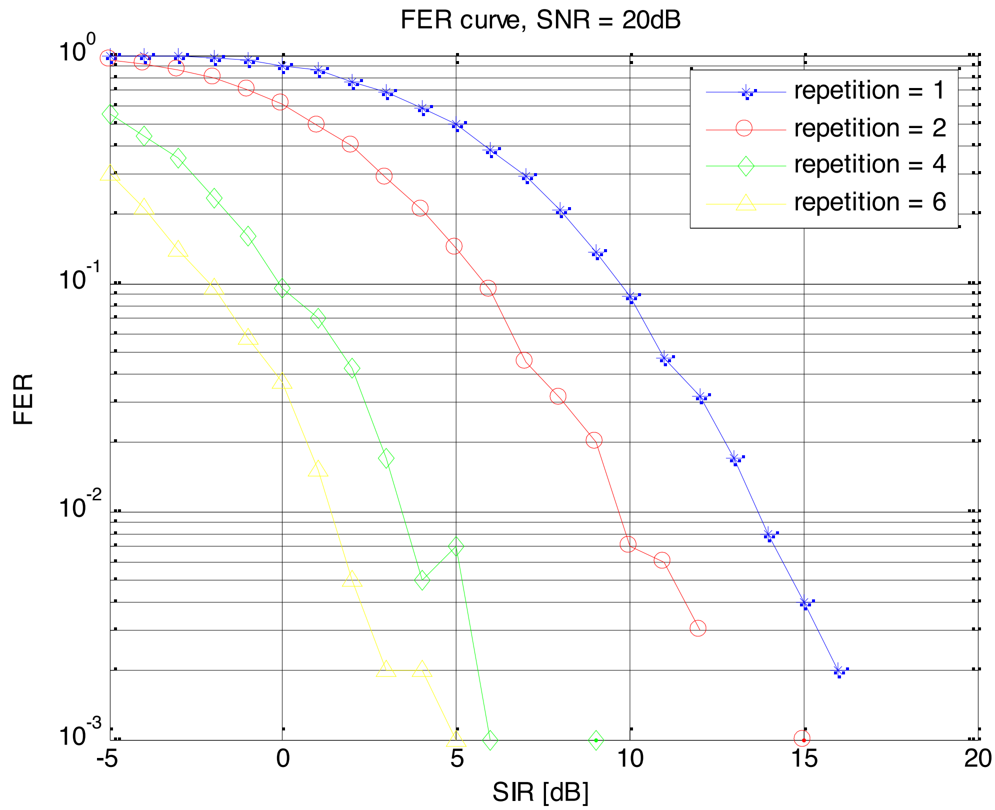

Figure 2.2.2: Performance of QPSK rate 1/2 versus SIR,
channel ITU-Ped-B (both desired signal and interferer), full loading.

As can be seen, repetition x6 is not enough in order to obtain reasonable performance with FER=0.01. Since SIR of ~13dB is required (without repetition), in order to be able to work with SIR of 0dB roughly 13dB of processing gain is required. The repetition code supplies ~7.8dB gain, so additional ~5dB are required.

2.4. Partial loading concept for reuse 1

Another method of increasing the processing gain is using partial loading. I.e. the assumption is that the permutation randomizes the choices of subcarriers for different cells (depending on IDCELL), and the BS uses only subchannels 0..(L-1) out of N, which is referred to as loading factor of L/N.

As a result, the average SIR on the subchannels used by the serving BS is reduced by the loading factor. The reason is that the probability of hit from another BS on each subcarrier is equal to the loading factor.

Partial loading enables increase of the processing gain up to the factor of the number of subchannels. Using loading factor of 1/3 supplies additional processing gain of 4.8dB, which compensates for the missing processing gain. This parameter is completely controlled by the BS and can be designed according to the specific system deployment.

2.5. Permutation support for partial loading

In order for partial loading to be efficient in reducing SIR, pseudo-random or uniform collisions between subchannels in different cells are required. What we require is that the average hit ratio between subchannels 0-(L-1) in IDCELL1 and subchannels 0-(L-1) in IDCELL2 will be approximately L/N. To give an extreme example, AMC permutation doesn't support this structure since subchannels 0-(L-1) collide in all base stations, and therefore there is no SIR gain from reducing the loading. From this reason use of AMC requires some coordination between BS or other methods to reduce SIR.

2.5.1. Downlink

In the downlink, the following permutations support partial loading:

PUSC, when outer permutation seed is different for each cell (derived from IDCELL or DL_PermBase)
FUSC
OFUSC

Explanation regarding the structure of PUSC:

PUSC is structured from two permutations, referred to as "inner" and "outer".
The outer permutation is responsible to select the clusters used by each major group (using the randomization sequence).
Each of the 6 major groups holds a continuous group of subchannels (12 or 8 in 2048 FFT case). By default, each two major groups are allocated to a segment.
The inner permutation is responsible for selecting the subcarriers for each subchannel over these clusters.
So when the outer permutation seed is 0, then segments 0,1,2 (groups {0,1}{2,3},{4,5}) consist of orthogonal set of subcarriers over all cells. When the outer permutation seed is different between cells, the selection of clusters for each major group changes, and we get different (pseudo random) sets in each cell.

2.5.2. Uplink

UL-PUSC mainly supports reuse 1 deployment (since change of IDCELL mixes all subchannels). It can also support partial reuse (like reuse 3) but with reduced performance (this is obtained only by fixing IDCELL across cells, and choosing orthogonal sets of subchannels, in which case there is no spreading of interference between cells with the same choice of subchannels.

UL-OPUSC supports both reuse 1 and reuse 3 in a natural way.

2.6. Problem statement

As explained above, PUSC has two modes, one suitable for reuse 1 and one for reuse 3. However, in the first zone in PUSC the seed of the outer permutation is set to "0", therefore as explained in 2.5.1 above, this is suitable only for reuse 3 deployment.

Since the FCH maps are in the first zone, this forces frequency planning in the system in order for SS to be able to register and obtain map information, so it is impossible to deploy a reuse 1 system, in spite of existing support in this mode in other zones (except the first).

The reason is that even if partial loading is employed in the first zone, the first major group will always collide with the first major group of any other segment with the same number, so the first slots of the FCH and the map will suffer from low SIR.

2.7. Proposed solution

The solution to this problem is straightforward and simple, by enabling to optionally set the outer permutation seed to IDCELL in the first zone. We propose that the outer permutation base may be either 0 or IDCELL (but constant over time), and the SS should blindly find the correct value by scanning (trying each one). This solution doesn't remove any deployment option that currently exists.

3. Changes summary

8.4.6.1.2.1.1 Downlink subchannels subcarrier allocation in PUSC

[Change the text on p.141, line 33 and on, item #2 as follows (change marked in blue/~~red~~)]

2) Renumbering the physical clusters into logical clusters using the following formula:
LogicalCluster = RenumberingSequence((PhysicalCluster+13*~~IDcell~~DL_PermBase) mod 120) ~~In the first PUSC zone of the downlink (first downlink zone), the default used IDcell is 0~~. In the first PUSC zone of the downlink (first downlink zone) the default used DL_PermBase ~~is 0~~ shall be set to either 0 or IDCELL, and will be constant across frames. When the 'Use all SC indicator=0' in the STC_DL_Zone_IE(), DL_PermBase is replaced with 0. For All other cases DL_PermBase parameter in the STC_DL_Zone_IE() shall be used. The SS is required to blindly scan for the value of DL_PermBase used in the cluster permutation for the first zone.