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Re:	Response to IEEE 802.16m-08/003r7 " IEEE 802.16m System Description Document (SDD)"
Abstract	This document proposes some detailed issues for CSSI implementation, including interleaver design, channel estimation and other requirements.
Purpose	For discussion and approval by TGm.
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Implementation issues for CSSI-based system

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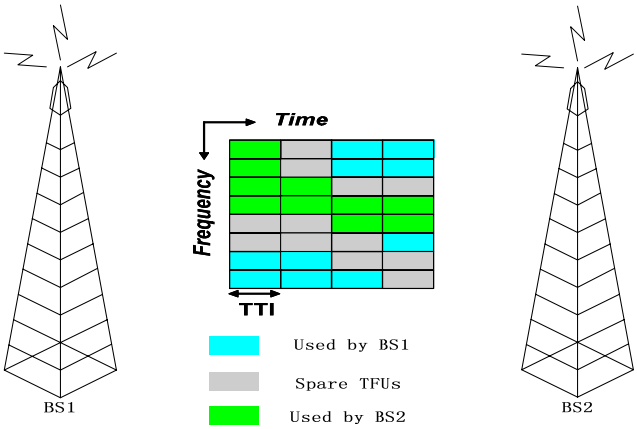
1. Introduction

CSSI (Cell/Sector-Specific Interleaving) is a potential technology which aims at suppressing the inter-cell/sector interference. The principle of CSSI is to employ distinct interleaving patterns in the neighbouring cells/sectors so that the UE can distinguish the signals from different cells/sectors by means of cell/sector-specific interleavers.

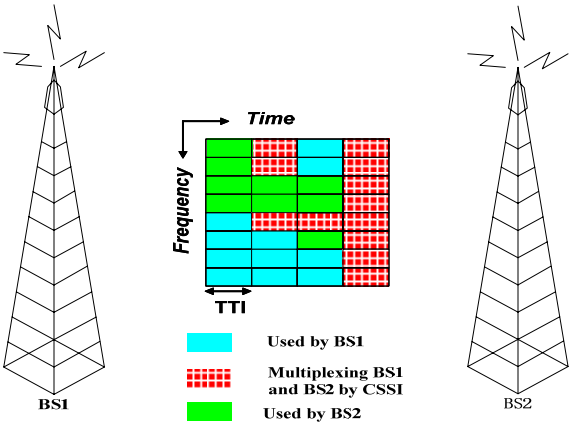
In this document, some detailed issues for CSSI implementation are proposed, including interleaver design, channel estimation and other requirements.

2. Implementation Issues

In an OFDM system, two neighbouring cells/sectors may first try to avoid reusing a chunk in the cell/sector-edge area by using inter-cell/sector interference coordination, as shown in Fig.1 (a). However, if the two cells/sectors have to reuse a chunk in the cell/sector-edge area (e.g. both the cells/sectors are heavy-loaded, or too complex to perform the interference coordination), CSSI provides an alternative way to mitigate the inter-cell/sector interference, as shown in Fig.1 (b). Some issues should be considered for implementing CSSI or iterative multi-cell/sector detection. Channel estimation and interleaver design should be carefully considered to enable CSSI. Multi-cell/sector detection will bring some extra requirements on e.g. synchronization and chunk size. However, when only a single-cell/sector detection is employed, these requirements can be released.



(a)



(b)

Fig.1. (a) Chunk allocation based on TDMA/FDMA

(b) Chunk allocation based on TDMA/FDMA and CSSI

2.1 Interleaver design

CSSI requires a channel interleaving through the whole a code block. For example, if a chunk contains M subcarriers and N OFDM symbols, the interleaver depth should be M×N. Since a number of random interleavers are required, the random interleaving, rather than block interleaving, should be used. The well-known random interleavers, e.g. s-random interleaver, could be considered. Of course a more powerful interleaver will bring a larger performance gain.

2.2 Channel estimation in interference environment

Channel estimation need to be performed in an interference environment. Thus the pilot patterns of the neighbouring cells/sectors should be orthogonal to each other. The orthogonal pilot design has been well investigated in MIMO channel estimation.

2.3 Synchronization Requirement for multi-cell/sector detection

If CSSI is only used for signal randomisation and interference whitening, the inter-cell/sector synchronization is not required. However, if the performance gain provided by interference cancellation is desired, the use of multi-cell/sector detection will introduce the requirement to inter-cell/sector synchronization. (The inter-NodeB synchronization should be available for supporting multi-NodeB MBMS.) However, even though the neighbouring cells/sectors transmit signals simultaneously, the timing offsets between cells/sectors (due to the different distances to the UE) may result in self-interference. Let ΔT_{offset} denote the timing offsets between adjacent cells/sectors (as shown in Fig.2), $\Delta T_{delay-spread}$ denote the channel delay spread, and T_g denote the CP length, if $\Delta T_{offset} + \Delta T_{delay-spread} < T_g$, the self-interference can be avoided. If $\Delta T_{offset} + \Delta T_{delay-spread} > T_g$, the self-interference should be much weaker than the inter-cell/sector interference, hence will only result in a margin degradation.

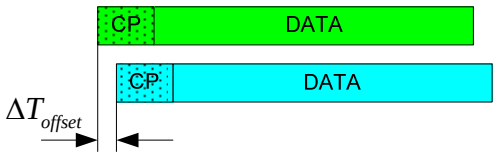


Fig.2 Illustration of asynchronization between Node-Bs/sectors

2.4 Requirement to chunk size for multi-cell/sector detection

To implement a low-complexity multi-cell/sector receiver, the neighbouring cells/sectors should adopt the same chunk allocation for the reused time-frequency resource. In other words, the corresponding chunks in the neighbouring cells/sectors should contain the same number of subcarriers and symbols.

Of course, if only the single-cell/sector detection is employed at the receiver, this condition does not need to be satisfied.

3. Proposed Text for SDD

Insert the following text into Interference mitigation using cell/sector-specific interleaving (i.e. Chapter 20 in [X]):

---------- Text Start ----------

20.4 Interference mitigation using cell/sector-specific interleaving

20.4.x Implementation Issues

Some issues could be considered for implementing CSSI or iterative multi-cell/sector detection. Channel estimation and interleaver design could be carefully considered to enable CSSI. Multi-cell/sector detection will bring some extra requirements on e.g. synchronization and chunk size. However, when only a single-cell/sector detection is employed, these requirements can be released.

20.4.x.1 Interleaver design

CSSI requires a channel interleaving through the whole a code block. For example, if a chunk contains M subcarriers and N OFDM symbols, the interleaver depth should be M×N. Since a number of random interleavers are required, the random interleaving, rather than block interleaving, can be used. The well-known random interleavers, e.g. s-random interleaver, could be considered. Of course a more powerful interleaver will bring a larger performance gain.

20.4.x.2 Channel estimation in interference environment

Channel estimation need to be performed in an interference environment. Thus the pilot patterns of the neighbouring cells/sectors should be orthogonal to each other. The orthogonal pilot design has been well investigated in MIMO channel estimation.

20.4.x.3 Synchronization Requirement for multi-cell/sector detection

If CSSI is only used for signal randomisation and interference whitening, the inter-cell/sector synchronization is not required. However, if the performance gain provided by interference cancellation is desired, the use of multi-cell/sector detection will introduce the requirement to inter-cell/sector synchronization. (The inter-NodeB synchronization should be available for supporting multi-NodeB MBMS.) However, even though the neighbouring cells/sectors transmit signals simultaneously, the timing offsets between cells/sectors (due to the different distances to the UE) may result in self-interference. Let ΔT_{offset} denote the timing offsets between adjacent cells/sectors (as shown in Fig. 20.4.x-1), $\Delta T_{delay-spread}$ denote the channel delay spread, and T_g denote the CP length, if $\Delta T_{offset} + \Delta T_{delay-spread} < T_g$, the self-interference can be avoided. If $\Delta T_{offset} + \Delta T_{delay-spread} > T_g$, the self-interference is much weaker than the inter-cell/sector interference, hence it will only result in a margin degradation.

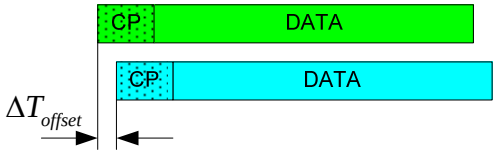


Fig.20.4.x-1 Illustration of asynchronization between Node-Bs/sectors

20.4.x.4 Requirement to chunk size for multi-cell/sector detection

To implement a low-complexity multi-cell/sector receiver, the neighbouring cells/sectors could adopt the same chunk allocation for the reused time-frequency resource. In other words, the corresponding chunks in the neighbouring cells/sectors could contain the same number of subcarriers and symbols.

If only the single-cell/sector detection is employed at the receiver, this condition does not need to be satisfied.

---------- Text End ----------