Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Beamforming Aided Frame Structures**
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Source(s)	Pei-Kai Liao, Chih-Yuan Lin, Ciou-Ping Wu, and Paul Cheng MediaTek Inc. No.1, Dusing Road 1, Science-Based Industrial Park, Hsinchu, Taiwan 300, R.O.C. pk.liao@mediatek.com peikai_liao@hotmail.com chihyuan.lin@mediatek.com paul.cheng@mediatek.com
Re:	IEEE 802.16m-07/047, "Call for Contributions on Project 802.16m System Description Document (SDD)" for the following topic: 1. Multiple antenna techniques, specifically as related to frame structure
Abstract	This contribution proposes an beamforming aided frame structure to improve system bandwidth efficiency and to manage inter-cell interference as well.
Purpose	Propose to be discussed and adopted by TGm for the use in Project 802.16m SDD.
Notice	
Release	
Patent Policy	

Beamforming Aided Frame Structure

Pei-Kai Liao, Chih-Yuan Lin, Ciou-Ping Wu, and Paul Cheng

MediaTek Inc.

1. Introduction

According to IEEE 802.16m System Requirements [1], 802.16m systems *shall* support advanced antenna techniques and interference mitigation schemes. It is well-known that antenna array can offer additional degrees-of-freedom to mitigate interference, and thus can further provide space division multiple access (SDMA) function for 16m cells. In a dense population environment, OFDMA combined with user-specific beamforming has the potential capability to simultaneously support all users so as to increase system overall bandwidth efficiency. This contribution will propose a beamforming aided three-dimensional frame structure to achieve the goal.

On the other hand, to support low-latency transmission the DL and UL durations defined in newly developed TDD frame structure of 16m systems are in general not synchronized with that of legacy systems [2]. Hence, adjacent co-channel interference is inevitable due to coexistence of 16m and legacy cells. An intuitive way to avoid such a problem is to set channel priority of 16m cells higher than that of legacy ones [2], e.g., to enforce legacy systems to stop operation when UL/DL transmission directions of both cells are different. However, this method would make the legacy cells stay in the idle mode for a long time within each frame period and thus significantly reduce the bandwidth efficiency of legacy cells. Since 16m systems support advanced antenna techniques and interference mitigation schemes, it is more reasonable to develop new schemes to manage interference, so as to make 16m cells operate properly and to maximally keep the performance of legacy cells unaffected as well. It will be shown that the proposed three-dimensional frame structure also allow the 16m BS to exploit beamforming gain to manage inter-cell interference, such that the loss of bandwidth efficiency of legacy cells can be reduced.

2. Beamforming Aided Three-Dimensional Frame Structure

First of all, it is noted that the proposed idea is essentially supplementary, and thus can be directly applied for all existing time-frequency two-dimensional frame structures, including both TDD and FDD schemes. Here, we take the TDD frame structure proposed in [3] as an example to explain the proposed idea. The proposed beamforming aided frame structure is shown in Figure 1. It is seen that the proposed idea attempts to utilize user-specific beamforming operation to further create the third dimension - space domain, in which additional users can be allocated such that the frequency and time resources are spatially re-used to increase bandwidth efficiency.

In the beginning of each frame, the BS broadcasts the preamble, FCH and MAP to all MSs by using omni-antenna. The MAP shall contain new IE to indicate which subchannels are assigned to support the SDMA mode and which MSs are invited to jointly use those subchannels. The rest of subchannels are assigned to the rest of MSs as in the conventional two-dimensional case. The BS now performs three-dimensional resource allocation, and thus more users can be served than in two-dimensional-only cases (see the second DL zone as shown in Figure 1 for example) within a cell. The expected communication scenario is shown in Figure 2.

Since the additional user-specific beamforming function is only for 16m users, for backward compatibility the legacy users can only exploit the time and frequency resources as stated in [3].

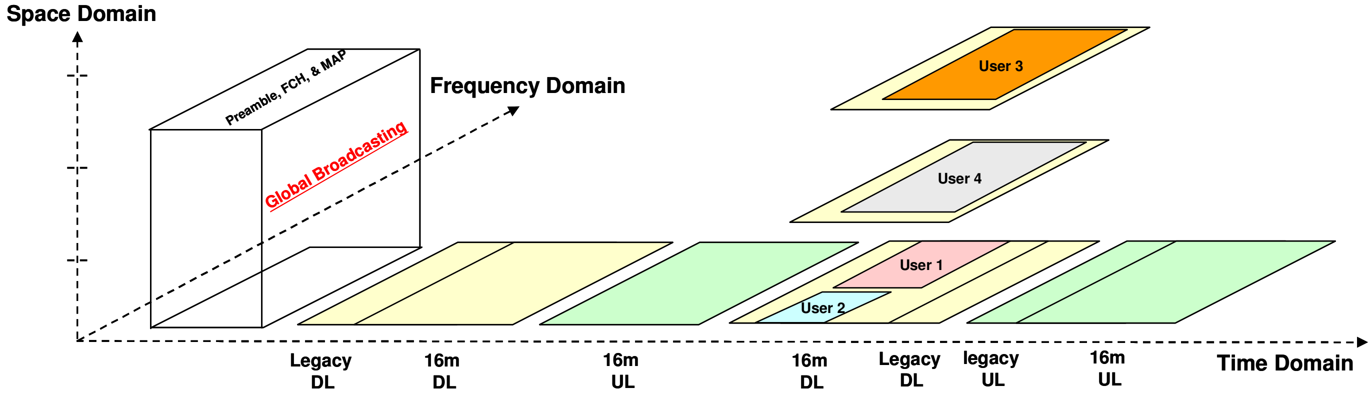

Figure 1. Proposed three-dimensional frame structure.

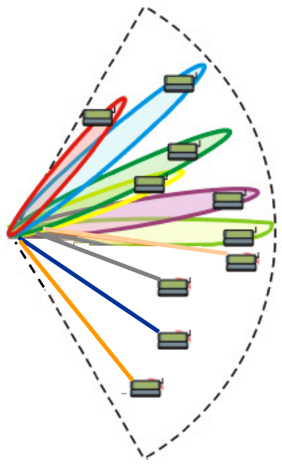

Figure 2. Expected communication scenario.

3. Inter-Cell Interference Mitigation

When DL/UL transmission directions of 16m and adjacent legacy cells are different, inter-cell interference appears to limit system performance. An intuitive way proposed in [2] is to suspend the transmission of legacy cells as the transmission direction mismatch occurs, leading to some loss of bandwidth efficiency (see Figure 3). In the followings, we will show that the proposed beamforming aided frame structure can further tackle the inter-cell interference. It is assumed that the 16m BS equips an interference sensor to estimate the second-order statistical characteristic of the adjacent cell interference on the subchannels of interest. Based on the estimation results, the BS can identify which subchannels are interfered. It is further assumed that the MSs which are assigned on those subchannels are also equipped multiple antennas (at least two). Then in the UL direction the BS can enable the beamforming operation on the interfered subchannels to perform BS-MS joint beamforming, so as to mitigate inter-cell interference (from DL transmissions of legacy cells) and avoid MS power leaking to legacy cells. On the other hand, in the DL direction the joint beamforming also allows the BS to control power emission direction, eliminating interference to legacy cells which are in UL transmission (see Figure 4 for schematic description of the mentioned inter-cell interference mitigation). With the mechanism described above, legacy cells can always operate well in either DL or UL transmission when the 16m cells are deployed nearby. The frame structure seen at the legacy MS end is shown in Figure 5. Compared with Figure 3, it is seen that there is no loss of bandwidth efficiency in legacy cells.

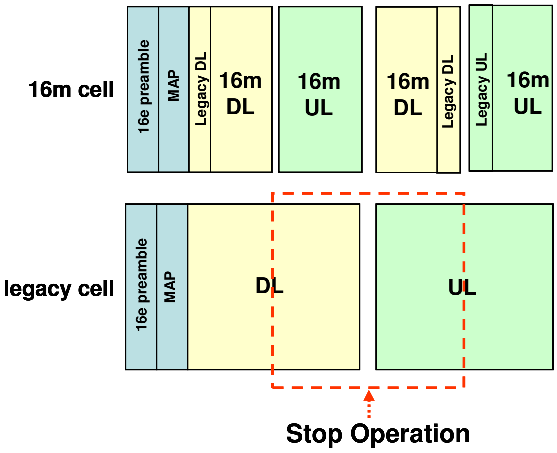

Figure 3. Frame structure seen by the legacy MS if beamforming operation is not applied in 16m BS.

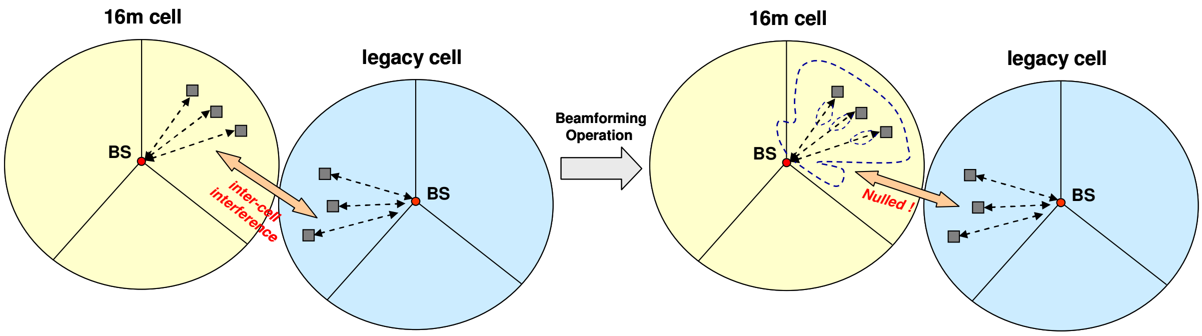

Figure 4. Schematic description of inter-cell interference mitigation.

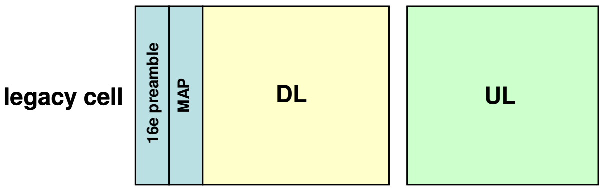

Figure 5. Frame structure seen by the legacy MS if beamforming operation is enabled in 16m cells.

4. Conclusion

This contribution proposes a beamforming aided three-dimensional frame structure, which provides better resource allocation flexibility than the conventional frame structure, leading to better bandwidth efficiency. Combined with an interference sensing mechanism, the proposed frame structure also can allow 16m BS to mitigate inter-cell interference from legacy cells. As a result, the adjacent legacy cells can maximally keep unaffected when the 16m cells are deployed nearby; this would largely increase overall system frequency reuse ratio. Though only TDD example is introduced in this contribution, same idea can be easily applied to FDD schemes (including full-duplex FDD and half-duplex FDD MS operations). In addition, interferences due to different transmission directions between neighboring cells do not exist in FDD scheme because downlink and uplink transmissions of this scheme are in different frequency bands. Thus, the proposed idea could achieve better performance improvement in FDD scheme, compared to TDD one.

REFERENCES

[1] IEEE 802.16m-07/002r4, "IEEE 802.16m System Requirements."

[2] IEEE C802.16m-07/265, "Implications of Backwards Compatibility on IEEE 802.16m Frame Structure."

[3] IEEE C802.16m-08/030, "Backward Compatible TDD 802.16m Frame Structure with Reduced Latency over Same or Different Channel Bandwidths."