Project	**IEEE 802.16 Broadband Wireless Access Working Group** <http://ieee802.org/16>
Title	**Inter-cell interference mitigation scheme when switching points not synchronized**
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Source(s)	Fang Huiying, Jerry Chow, Qu Hongyun, Xu Ling, Sean Cai ZTE Corporation Voice: [Telephone Number (optional)]] E-mail: fang.huiying@zte.com.cn *<http://standards.ieee.org/faqs/affiliationFAQ.html>
Re:	IEEE 802.16m-08/024 –Call for Contributions on Project 802.16m System Description Document (SDD); Interference Mitigation
Abstract	The contribution presents an inter-cell interference mitigation scheme when different DL:UL ratios are used in different cell clusters across the network.
Purpose	To be discussed and adopted by TGm for use in the IEEE 802.16m SDD
Notice	
Release	
Patent Policy	

Inter-cell interference mitigation scheme when switching points not synchronized

Fang Huiying, Jerry Chow, Qu Hongyun, Xu Ling, Sean Cai

ZTE Corporation

1 Introduction

In 16m SRD 802.16m-07/002r4, the text "In TDD mode, the DL/UL ratio should be adjustable. In the extreme, the IEEE 802.16m system should be capable of supporting downlink-only configurations on a given carrier." allows the configuration of different DL/UL ratios.

In one application of this requirement, different DL/UL ratios may be configured in cells of different deployment regions according to the DL/UL traffic requirement for each region in order to improve the overall system utilization. Cells in different deployment regions may have different DL/UL service requirements. For example, a downtown business-oriented area may experience a significantly higher proportion of voice traffic and therefore, would benefit from a more balanced DL/UL ratio versus a suburban area, which may be more dominated by internet data traffic.

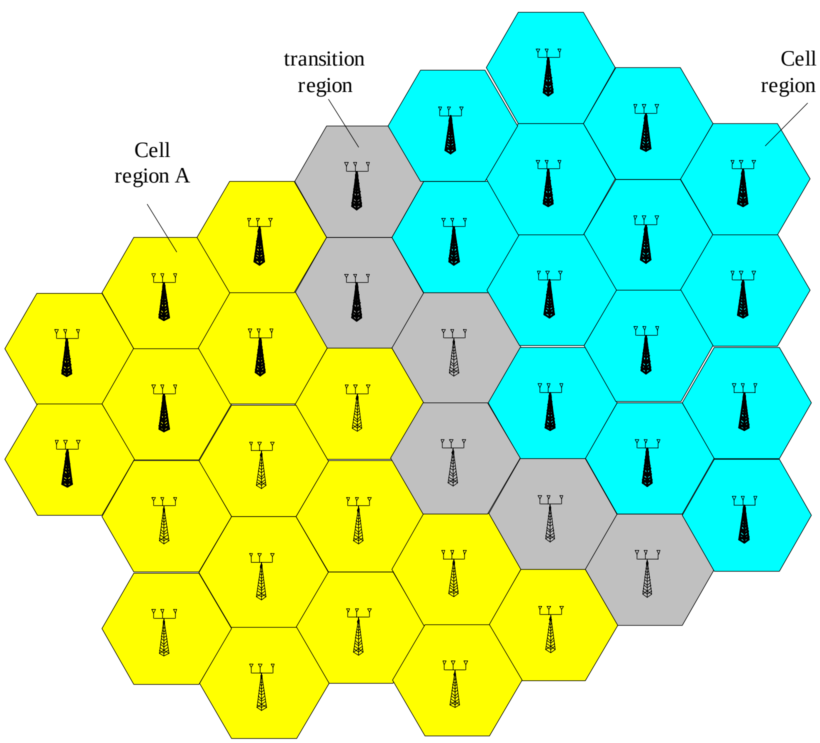

Fig 1. Cell regions with different DL/UL ratio requirement

If cells with different DL/UL ratio coexist in the neighboring regions, the problem of inter-cell interference due to switching points across these cells being not synchronized needs to be addressed.

This contribution proposes a scheme to configure different DL/UL ratio of cells in different deployment regions according to the DL/UL traffic requirement and introduce mute subframe in cells belonging to transition regions to resolve the inter-cell interference problems caused by switching points not synchronized across the neighboring deployment regions. This network deployment concept is shown in Fig. 1.

2 DL/UL ratio configuration in 16m

In 16m SDD, the number of switching points in each radio frame in TDD systems is either two or four, where a switching point is defined as a change of directionality, i.e., from DL to UL or from UL to DL. The DL/UL ratios that can be used in 16m system with two switching points are shown in Table 1. Since downlink-only configuration is an extreme instance, it is not list in this table.

Table 1: TDD DL/UL Configurations for Radio Frame

configuration	DL/UL Ratio	direction of subframe (D:downlink, U:uplink)							
		0	1	2	3	4	5	6	7
1	7:1	D	D	D	D	D	D	D	U
2	6:2	D	D	D	D	D	D	U	U
3	5:3	D	D	D	D	D	U	U	U
4	4:4	D	D	D	D	U	U	U	U
5	3:5	D	D	D	U	U	U	U	U
6	2:6	D	D	U	U	U	U	U	U
7	1:7	D	U	U	U	U	U	U	U

There are totally seven DL/UL ratio types in this table.

3 Proposed solution

In the cells belonging to the same deployment region, the switching point number and DL/UL ratio are the same. For example, the DL/UL ratios of all the cells belonging to deployment region A are the same (e.g. a DL/UL ratio of 6:2) and the DL/UL ratios of all the cells belonging to deployment region B are the same (e.g. a DL/UL ratio of 5:3). The DL/UL ratio in deployment region A is different from that in the deployment region B. In order to mitigate the inter-cell interference across the neighboring deployment regions, some cells between the different deployment regions are assigned as a transition region. In the cells that belong to transition regions, a mute subframe is configured in either the downlink or uplink part of the frame. If a subframe is configured as a mute subframe, there may be no transmission in this subframe. Some restricted use of mute subframe is FFS. The function of the mute subframe in the cells belonging to the transition region is to avoid the transmission of subframe with different link direction among the neighboring cells at the same time. Use of mute subframe can mitigate the inter-cell interference problem caused by switching point not synchronized across the neighboring deployment regions.

3.1 *Ralative DL/UL ratio difference between two neighboring deployment regions is only by one subframe*

In this scenario, the relative DL/UL ratio difference between deployment region A and B is by one subframe. The DL/UL ratio of cells belonging to the first deployment region A is M:(8-M), (M>1 and M<8), and the DL/UL ratio in cells belonging to the second deployment region B is (N-1):(8-N), (N>1 and N<8 where N=M-1). Single-layer transition region is used to mitigate the inter-cell interference problem; single-layer transition region means the DL/UL ratios of all cells belonging to transition region are the same. The DL/UL ratio of cells belonging to the transition region may be M:(8-M) or (N):(8-N). In order to mitigate the inter-cell interference problem caused by the DL/UL ratio difference between the two deployment regions. One downlink subframe or one uplink subframe adjacent to the DL/UL switching point will be configured as mute subframe. Since the specific subframe in the cells of the transition region is set as a mute subframe, the subframes that occur at the same time in two neighboring cells with different DL/UL ratio do not have different transmitting direction.

For example, the DL/UL ratio in deployment region A is 5:3 and the DL/UL ratio in deployment region B is 4:4. We can configure the DL/UL ratio in transition region to 5:3 and set the last downlink subframe (subframe 4) as the mute subframe, as shown in Fig 2. The transmitter of cells in the transition region will turn off the RF and not transmit any data or control signal in the mute subframe. Due to the mute subframe in the transition region, even subframe 4 in deployment region A and deployment region B have contrary transmitting direction, subframe 4 in the neighboring cells will not have contrary transmitting direction. The inter-cell interference problem caused by the DL/UL ratio not the same between deployment region A and B is mitigated in some extent.

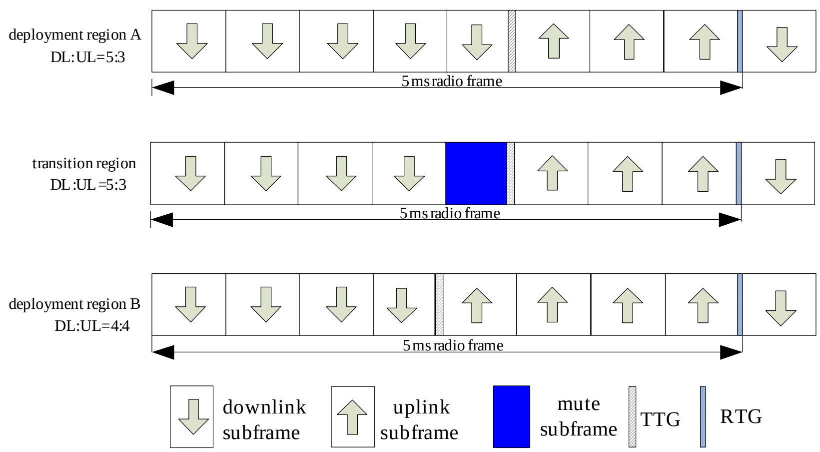

Fig 2 downlink mute subframe in single-layer transition regions

We can also configure the DL/UL ratio in transition region to 4:4 and set the first uplink subframe (subframe 4) as the mute subframe, as shown in Fig 3.

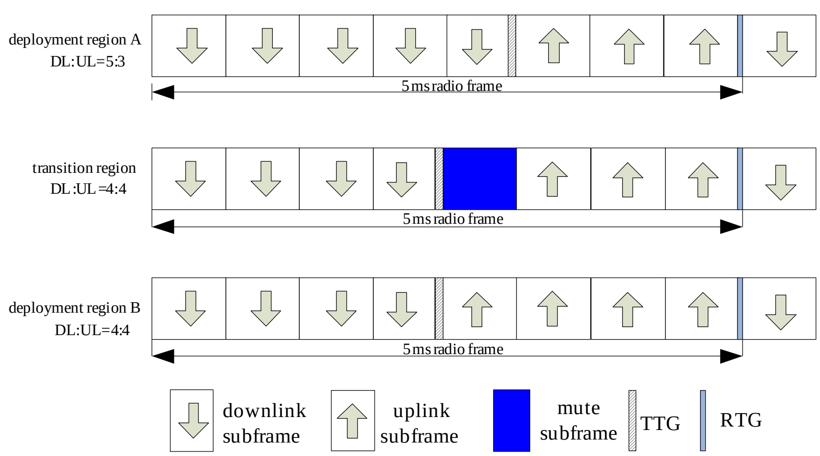

Fig 3 uplink mute subframe in single-layer transition regions

3.2 Relative DL/UL ratio difference between two neighboring deployment regions is by larger than one subframe

In this scenario, the DL/UL ratio of cells belonging to the first deployment region A is M:(8-M),(M>1 and M<8), and the DL/UL ratio of cells belonging to the second deployment region B is (M-L):(8+L-M),(L>1 and L< 7). Then, there needs to configure multiple-layer transition regions; multiple-layer transition region means the DL/UL ratios of cells belonging to different layers of transition regions are different. The layers of the transition regions are determined by the DL/UL ratio difference between the two deployment regions. The DL/UL ratio of cells belonging to one transition region layer shall be the same and the DL/UL ratio of cells belonging to different transition region layers may change gradually from deployment region A to deployment region B. Each layer of transition regions has its specific DL/UL ratio. The example of the deployment regions and corresponding transition region layers are shown in Fig 4.

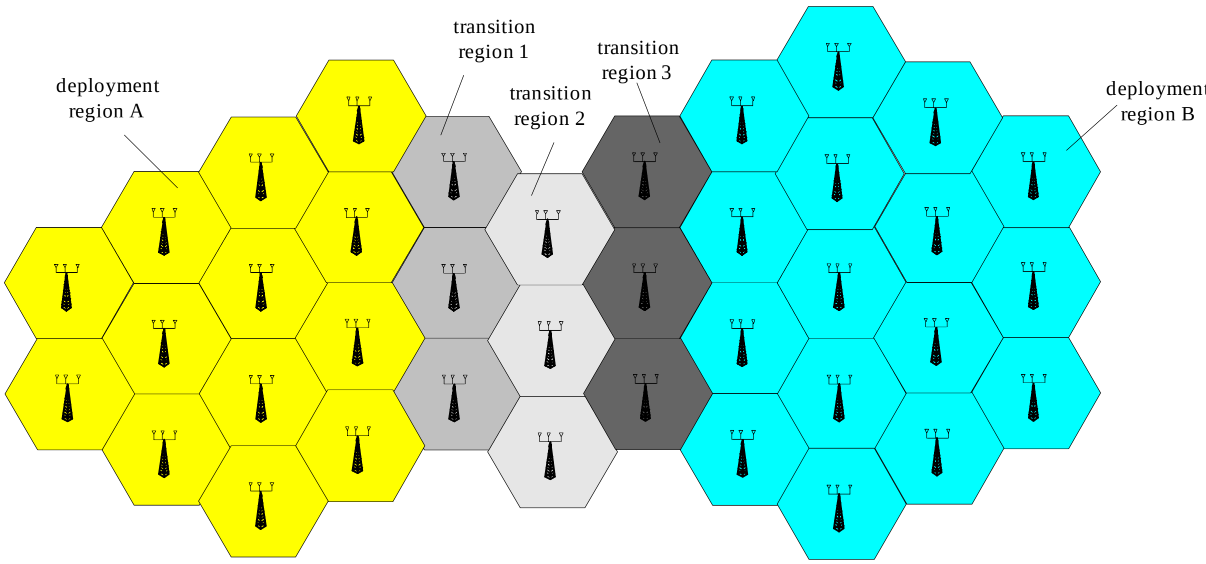

Fig 4 multiple-layer transition regions

Multiple-layer transition regions are used between different deployment regions to mitigate the inter-cell interference caused by the switching point not synchronized across the network. The layers of transition region will be determined by the difference of the DL/UL ratio between the neighboring two deployment regions. Cells belonging to different transition region layers may have different DL/UL ratio. The cells belonging to different transition region layers determine their specific DL/UL ratio based on the DL/UL ratios of the neighboring deployment regions.

In order to mitigate the inter-cell interference problem caused by the DL/UL ratio difference between two deployment regions. In the cells of each transition region layer, one downlink subframe or one uplink subframe near the DL/UL switching point will be configured as mute subframe. Since the subframe in the cells belonging to the transition regions is set as mute subframe, the subframes in two neighboring cells will never have different transmitting direction and the inter-cell interference problem caused by different DL/UL ratio in the neighboring deployment regions will not exist in some extent.

For example, the DL/UL ratio in deployment region A is 6:2 and the DL/UL ratio in deployment region B is 3:5. A three-layer deployment region will be configured to mitigate the inter-cell interference problem. From deployment region A to B, the transition region layers are transition region layer-1, transition region layer-2 and transition region layer-3 as shown in Fig 4.

To configure a downlink subframe as mute subframe is one way to mitigate the inter-cell interference problem as shown in Fig 5. First, we may set the DL/UL ratio of the cells belonging to transition region layer-1 to 6:2 and configure the last downlink subframe(subframe 5) of the cells in transition region layer-1 as mute subframe. Then, we set the DL/UL ratio of cells belonging to transition region layer-2 to 5:3 and configure the last downlink subframe(subframe 4) of the cells in transition region layer-2 as mute subframe. At last, we set the DL/UL ratio of the cells belonging to transition region layer-3 to 4:4 and configure the last downlink subframe (subframe 3) of the cells in transition region layer-3 as mute subframe. Due to the mute subframe in the cells belonging to each transition region layer, the subframe in the two neighboring cells will not have contrary direction and the inter-cell interference problem caused by the switching point not synchronized will not exist.

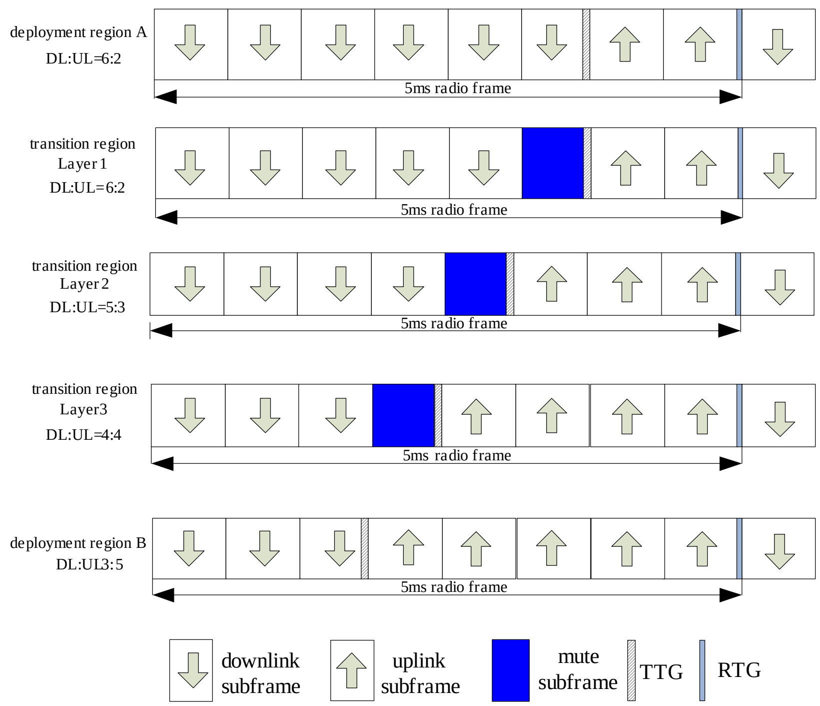

Fig 5 downlink mute subframe in multiple-layer transition regions

To configure an uplink subframe as mute subframe is another way to mitigate the inter-cell interference problem as shown in Fig 6. First, we may set the DL/UL ratio of the cells belonging to transition region layer-1 to 5:3 and configure the first uplink subframe(subframe 5) of the cells in transition region layer-1 as mute subframe. Then, we set the DL/UL ratio of cells belonging to transition region layer-2 to 4:4 and configure the first uplink subframe(subframe 4) of the cells in transition region layer-2 as mute subframe. At last, we set the DL/UL ratio of the cells belonging to transition region layer-3 to 3:5 and configure the first uplink subframe (subframe 3) of the cells in transition region layer-3 as mute subframe. Since the specific subframe in the cells of each transition region layer is set as a mute subframe, the subframes that occur at the same time in two neighboring cells with different DL/UL ratio do not have different transmitting direction and the inter-cell interference problem caused by the switching point not synchronized will not exist.

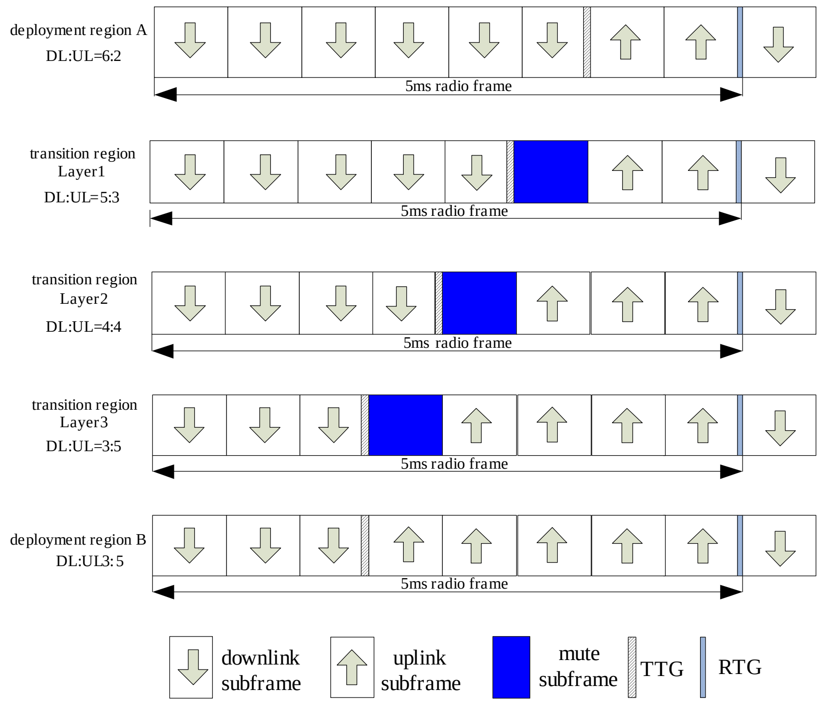

Fig 6 uplink mute subframe in multiple-layer transition region

3.3 Conclusion

In this contribution, the mute subframe is introduced to resolve the inter-cell interference problem caused by different DL/UL ratios across network. Based on this scheme, cells in different deployment regions can set the DL/UL ratio according to the DL/UL traffic requirement. The mute subframe in cells belonging to the transition regions will mitigate the inter-cell interference problem, and cells with different DL/UL ratio configuration can coexist in the network. If the DL/UL ratio difference between two deployment regions is larger than one subframe, multiple-layer transition regions will be configured. Cells belonging to different transition region layer will have different DL/UL ratio and only one subframe will be set as mute subframe in the cells of each transition region layer, which will reduce the performance influence to the cells in the transition regions.

4 Proposed Text for SDD

-- Text Start --

17. Solutions for Co-deployment and Co-existence

17.x. Solutions for Co-deployment

17.x.1 Solution for Co-deployment of cells with different DL/UL ratios across network

DL/UL ratio is a deployment-wide system parameter. The DL/UL ratio of the cells within one deployment region is the same. Different DL/UL ratios may be configured in cells of different deployment regions according to the DL/UL traffic requirement for each region in order to improve the overall system utilization.

If the neighboring deployment regions have different DL/UL ratio configuration, single-layer or multiple-layer transition regions are configured to resolve the inter-cell interference problem caused by the switching points of TDD radio frames within the different deployment regions not being synchronized. The layers of the transition regions are determined by the DL/UL ratio difference between the two deployment regions.

Mute subframe scheme (If a subframe is configured as a mute subframe, there may be no transmission in this subframe. Some restricted use of mute subframe is FFS) should be used to resolve the inter-cell interference problem caused by different DL/UL ratios between the neighboring deployment regions. In the cells of each transition region layer, one downlink subframe or one uplink subframe adjacent to the DL/UL switching point is configured as a mute subframe. Since the specific subframe in the cells of each transition region layer is set as a mute subframe, the subframes that occur at the same time in two neighboring cells with different DL/UL ratio do not have different transmitting direction and the inter-cell interference problem caused by the switching point not synchronized will not exist.

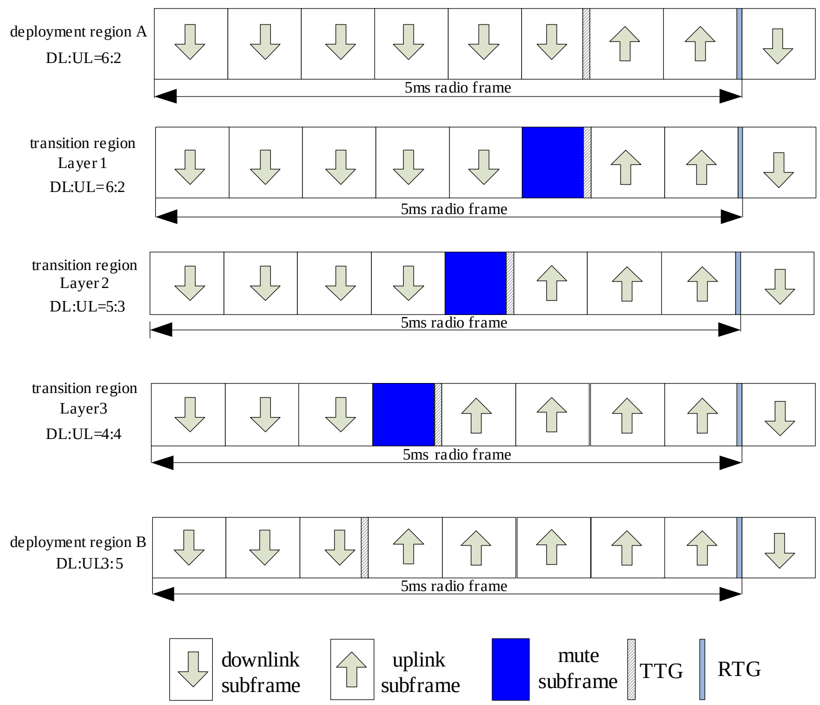

Figure xx Illustration of downlink mute subframes in multiple-layer transition regions

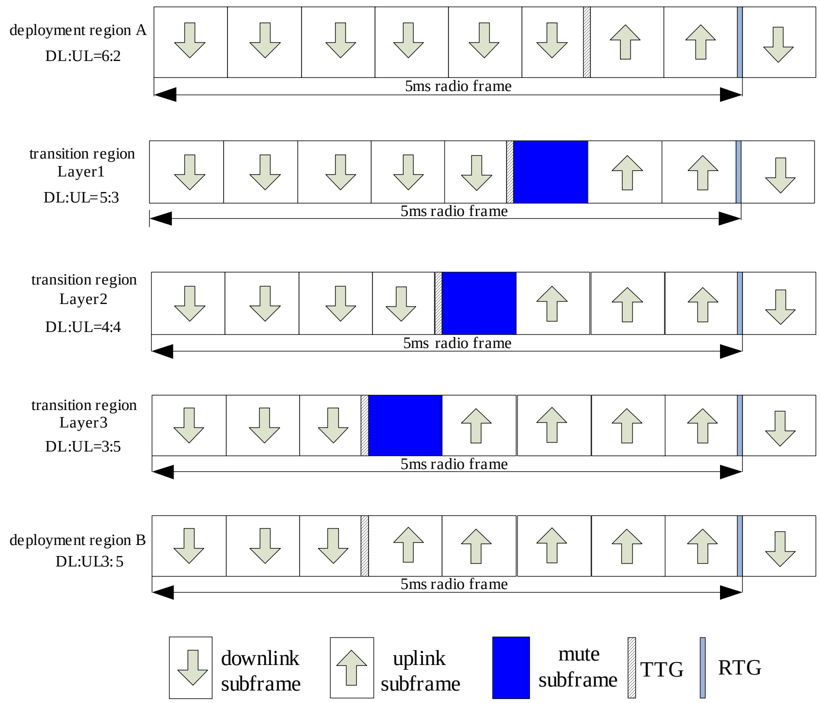

Figure xx Illustration of uplink mute subframes in multiple-layer transition regions

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5 References

[1] 80216m-07_002r4,