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Re:	IEEE 802.16m-08/016r1, "Call for SDD Comments and Contributions"
Abstract	Proposal on IEEE 802.16m Frame Structure for Co-deployment with other TDD Networks In IEEE 802.16m requirements (IEEE 802.16m-07/002r3), a requirement of co-deployment with other networks is clearly defined in the section 8.3. Especially, it is anticipated that IEEE 802.16m is to be deployed in the same frequency band on an adjacent carrier such as TD-SCDMA and its LTE. In this proposal, coexistence support in frame structure is considered and corresponding text is proposed.
Purpose	To be discussed and adopted by TGm for the 802.16m SDD.
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Coexistence Support in Frame Structure

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1. Introduction and Background

In IEEE 802.16m requirements (section 8.3 [1]), a co-deployment requirement with other networks has been defined clearly. Generally speaking, this requirement can be summarized as:

1) It is envisioned that the IEEE 802.16m can be deployed in the same or overlapping geographical areas with other wireless networks based on different Radio Access Technologies (RAT), with same / different network topology.

2) Moreover, it is anticipated that IEEE 802.16m is to be deployed in the same / adjacent RF bands as non IEEE 802.16m legacy networks.

   a) These non-802.16 networks may operate in the adjacent licensed frequency bands such as CDMA 2000, 3GPP (e.g., GSM, UMTS, HSPA and LTE).

   b) In unlicensed bands such as 802.11x networks

   c) More importantly in the same frequency band on an adjacent carrier such as TD-SCDMA (LCR-TDD)

3) As a result, the 802.16m standard shall provide a method whereby coexistence of networks specified on the basis of the IEEE 802.16m amendment with these networks, as well as other IEEE 802.16 networks can be achieved from the perspective of being both an interferer and being a victim depending on the coexistence scenarios defined in IEEE 802.16m requirement.

In the requirements aforementioned, the coexistence and co-deployment between LCR-TDD (including its evolution E-UTRA architecture) and IEEE 802.16m shall be emphasized. This is due to the fact that both IEEE 802.16m TDD and LCR-TDD / E-UTRA TDD belong to TDD mode, and it is possible to use the same frequency band but adjacent carriers or adjacent frequency bands, being allocated by ITU. Therefore, the interference mitigation with adjacent frequency bands cannot be ignored when we consider this coexistence support in frame structure.

Generally speaking, the adjacent-band based interference can be divided into twin sub-kinds.

1) Sub-kind 1: interference between DL of two TDD architectures / UL of two TDD architectures

2) Sub-kind 2: interference between DL of TDD architecture 1 and UL of TDD architecture 2 / between UL of TDD architecture 1 and DL of TDD architecture 2.

For the sub-kind 1, mainly it relates to the RF mask design for both TDD mode architectures, which does not be involved in this proposal. It will be discussed the future.

For the sub-kind 2, mainly it relates to the radio frame design of IEEE 802.16m, which is the most important

discussing topic involved in this proposal.

According to the section 8.3.2 (Coexistence Scenarios) of IEEE 802.16m requirement, the typical scenarios of coexistence / co-deployment between IEEE 802.16m and LCR-TDD/E-UTRA are proposed in the following figure, which clearly shows the adjacent-band based interference possibly existed in the coexistence / co-deployment aforementioned.
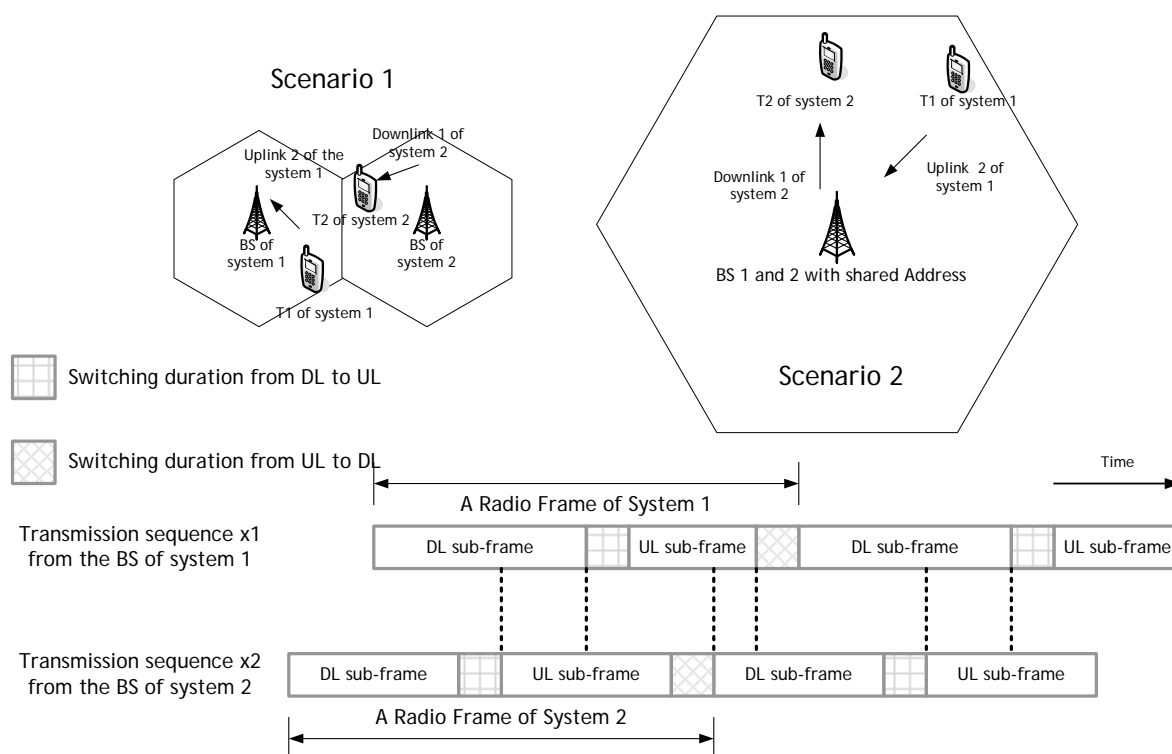

Figure 1 Possible adjacent-band based interference in the coexistence of two TDD architectures

It is clearly shown in the figure 1 that no matter in Scenario 1 or Scenario 2, the interference of sub-kind 2 is possible to exist, when the DL sub-frame of system 1 and UL sub-frame of system 2 / UL sub-frame of system 1 and DL sub-frame of system 2 are intersected. For example, when Terminal 2 of system 2 receives the downlink 1 of system 2, simultaneously, Terminal 1 of system 1 transmits the uplink 2 of system 1. Thus, the receiving of T2 of system 2 is interfered by the transmission of T1 of system 1.

Obviously, this kind of intersection should be considered during the coexistence support of IEEE 802.16m radio frame structure. Concretely speaking, during the frame structure design, the DL sub-frame of different architectures and UL sub-frame of different architectures shall be completely synchronized respectively as possible as we can.

2. Design Considerations

Some important considerations in the design of the new frame structure were enumerated in the following descriptions.

1) Performance of IEEE 802.16m shall be optimized as possible as we can, under the condition of this kind of

coexistence / co-deployment is satisfied.

  a) The radio resource efficiency of IEEE 802.16m shall be kept as possible.

  b) The legacy requirement of IEEE 802.16m shall be kept.

2) The DL sub-frame of system 1 vs. system 2 / UL sub-frame of system 1 vs. system 2 should be completely synchronized

  a) The ratio of DL to UL shall be related between LCR-TDD / LTE and IEEE 802.16m. For example, the DL vs. UL ratio of IEEE 802.16m can refer to that of LCR-TDD / LTE.

  b) Under the condition that a common referring point is selected, a frame-offset is proposed for this DL / UL sub-frame synchronization between LCR-TDD LTE / IEEE 802.16m.

3) Under the condition that this synchronization cannot be accomplished at all, then

  a) Respective time resources therefore respective OFDMA symbols should be especially processed in order to mitigate this intersection based interference, such as being idle or reducing the transmission power.

  b) Especially it is suggested that the 1st DL sub-frame and the 1st UL sub-frame should be complete kept without any special processing.

This method can be described as the following examples in the figure 2.
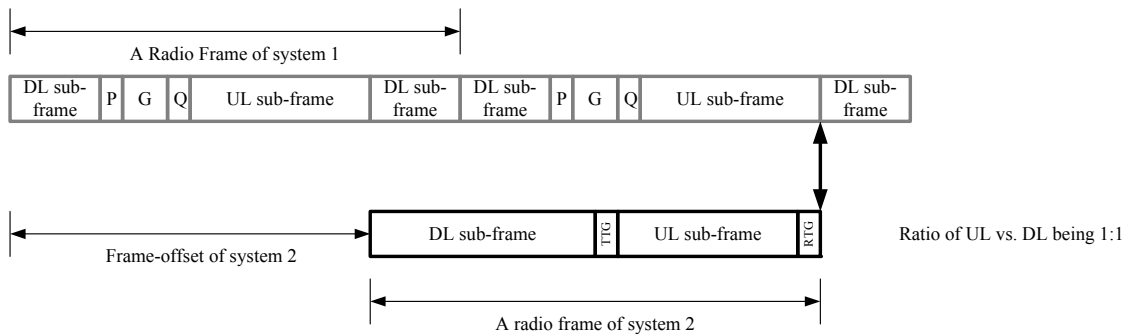
Case 1: the radio of UL: DL of system 1 is 1:1
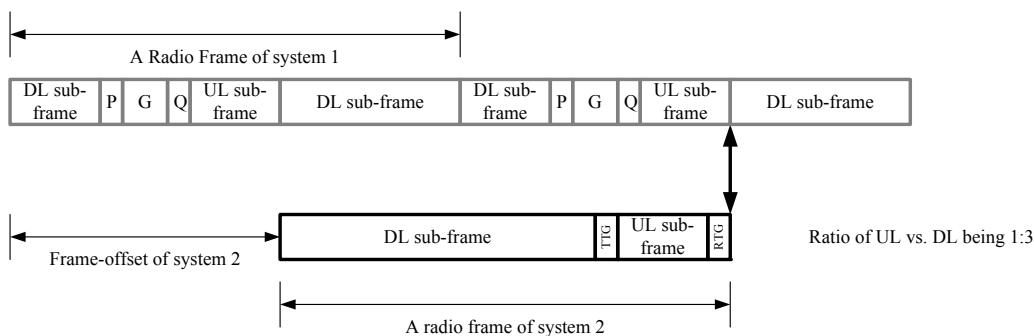
Case 2: the radio of UL: DL of system 1 is 1:3

Figure 2 IEEE 802.16m frame structure by the methods proposed

3. Proposed Frame Configuration for Coexistence with LCR-TDD/TD-SCDMA

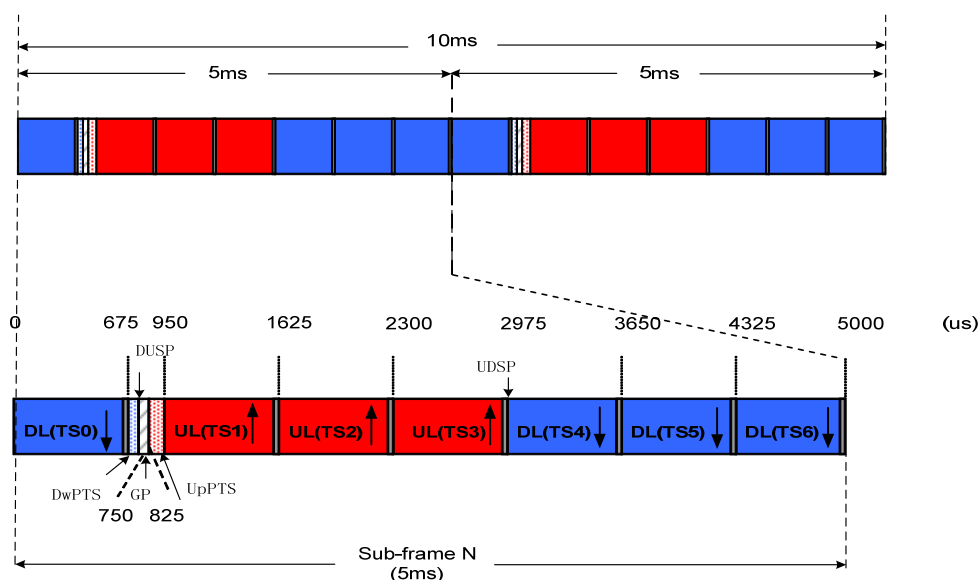The frame structure of LCR-TDD/TD-SCDMA is shown in Figure 3.

Figure 3: LCR-TDD/TD-SCDMA Radio frame structure

Frame shifting

Since the transmission frames in air interface is continuous in time, so the frame shifting is introduced as the measure to reduce the DL/UL interference between coexistence systems.

The basic principle of frame shifting is:

- **DL Transmission**: Secondary system (in following example, IEEE 802.16m TDD) can only allocate its DL transmission within the Primary system (in following example, TD-SCDMA) DL transmission time slots;

- **UL Transmission**: Secondary system (in following example, IEEE 802.16m TDD) can only allocate its UL transmission within the Primary system (in following example, TD-SCDMA) UL transmission time slots;

Design for IEEE 802.16m TDD

In following example, the LCR-TDD deployment scenario of DL:UL configuration with 4:3 is set as example.

Note: The numerical results shown in following is derived on the assumption that the number of OFDMA symbols per mini-frame is 6 for 1/8 CP length. For other parameters, the numerical results will be computed and changed accordingly.

■ **DL:UL configuration**

From general design principle, we should configure the DL:UL of IEEE 802.16m TDD as 5:3, which means the last 2 symbols of DL should be set "idle".

■ **Frame offset configuration**

Δt=2975us can be used as the frame shifting parameter which means the starting point of IEEE 802.16m TDD frame N should align with the UDSP(UL-DL Switching Point) of TD-SCDMA subframe N.
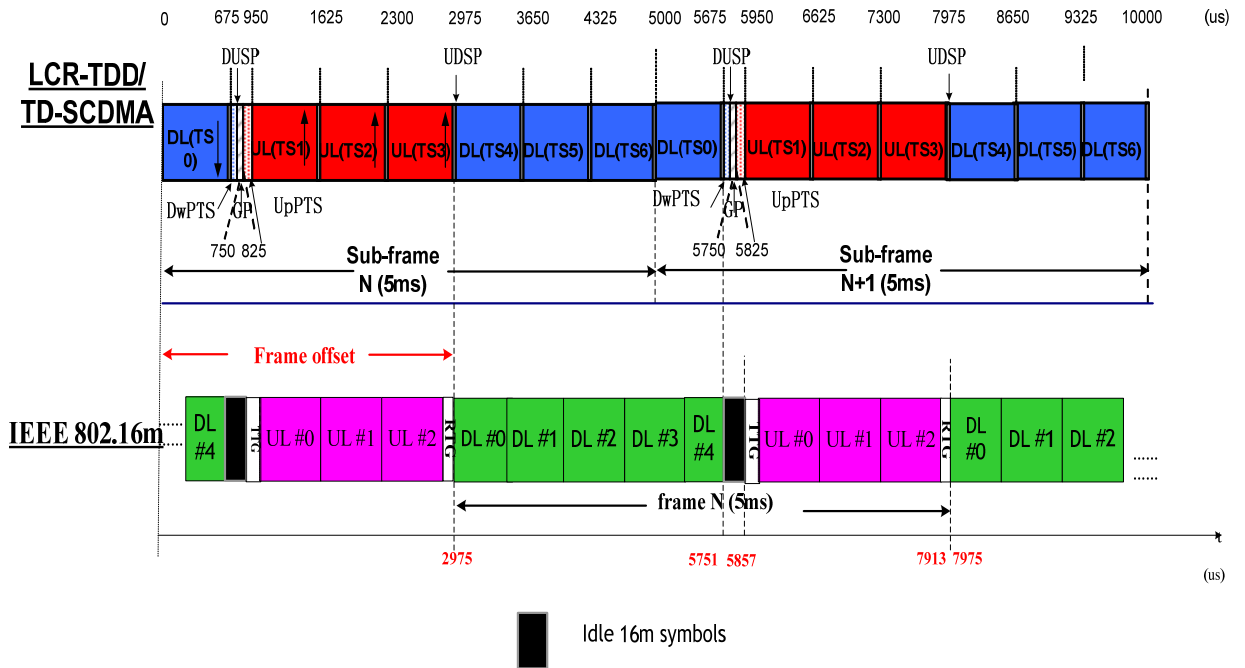

Figure 4: Radio frame coexistence structure of LCR-TDD/ TD-SCDMA and IEEE 802.16m TDD

4. Proposed Frame Configuration for Coexistence with E-UTRA TDD

In [3], an uniformed TDD frame structure has been proposed and defined, as the descriptions of the following figure.
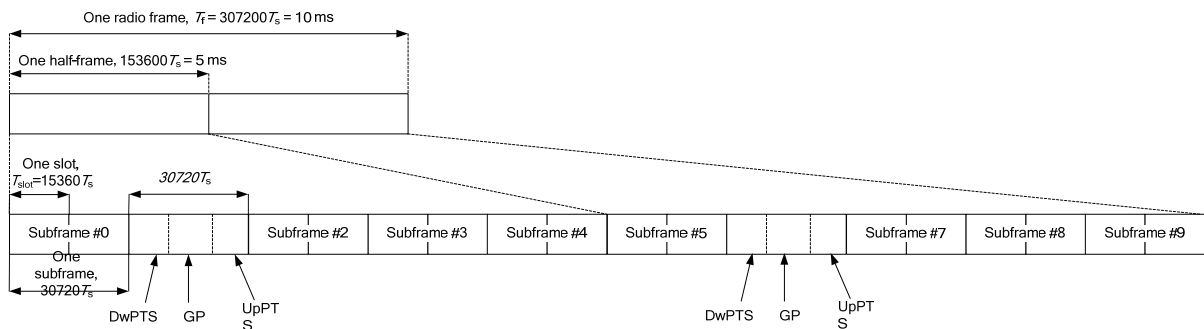

Figure 5: TDD LTE Radio frame structure of TDD mode in TS36.211

As shown in the Figure 5, one radio frame is 10ms, including twin half-frames with 5ms. Thus, the radio frame can be divided into two types.

For the 1st type, the unit of radio frame is 5ms (one half-frame), moreover with the following definitions:

1) 5 ms can be equally divided into 5 sub-frames, with the unit of 1ms.

2) In the 2nd sub-frame, Dw-PTS (P), GP (G) and Up-PTS (Q) have been defined. In 3GPP LTE, it is defined that in one sub-frame, 14 symbols can be allocated. It should be noted these parameters can be configurable. For example, Dw-PTS area can hold 2 or 3 symbols (at least for the 1st one is P-SCH), GP can hold 1, 2, 3, 4, 5 … 11 symbols being related to the cell coverage, Up-PTS can hold the resting ones (at least two symbols is for short RACH). According to the specification of 3GPP LTE, the detailed configuration can be shown in the table 1.

3) A sub-frame can hold two slots with unit of 0.5ms.

4) The 1st sub-frame shall be DL, and the 3rd one shall be UL, and other sub-frames can be configurable between DL and UL.

For the 2nd type, it is same as the 1st one, except that,

1) Dw-PTS, GP and Up-PTS can be absent in the 2nd half-frame

2) All of sub-frames in the 2nd half-frame shall be DL.

Table 1 the configuration for Dw-PTS, GP and Up-PTS allocation

Configuration	Normal CP			Extended CP		
	DwPTS	GP	UpPTS	DwPTS	GP	UpPTS
0	3	10	1	3	8	1
1	9	4	1	8	3	1
2	10	3	1	9	2	1
3	11	2	1	10	1	1
4	12	1	1	3	7	2
5	3	9	2	8	2	2
6	9	3	2	9	1	2
7	10	2	2	-	-	-
8	11	1	2	-	-	-

Assuming that Dw-PTS equals to 10 and GP equals to 3 and Up-PTS equal to 1, the frame structure special design for coexistence / co-deployment can be proposed in the following table 2 according to the methods in the design consideration.

The key point in this section, is to show how to make it feasible/possible for the two TDD systems to coexist within the bounds of the aforementioned generic frame structure (figure 2), by using the proposed frame shifting scheme.

Against different possible Ratio between UL and DL of TDD LTE, by using the proposed frame shifting based solution, the respective processing results can be obtained in the following table. In addition, it should be clearly noted that the numerical results shown in the following table is derived on the assumption that the number of OFDMA symbols per mini-frame is 6 with 1/8 CP length, TTG and RTG follow the suggestions from WiMAX Forum.

Table 2 frame-shifting based solution for IEEE 802.16m being coexisted for TDD LTE

Ratio of TDD LTE (UL : DL)	Ratio of IEEE 802.16m (UL:DL)	Frame offset proposed	Time duration of possible intersection	Default OFDMA symbols possibly impacted
1:1	3:5	4000μs	6927.81μs – 6981.78μs	1
3:1	5:3	62.46μs	0	None
1:3	1:3	3062.46μs	0	None
1:2	5:11	62.46μs	0	None
2:7	3:13	9000μs	11927.81μs – 11981.78μs	1
1:8	1:15	12215.62μs	11927.81μs – 12215.62μs	3

According to the calculation result, the following conclusions can be obtained.

Fortunately in some cases, this kind of coexistence / co-deployment can be guaranteed by using the proposed frame-shifting based solutions, under the condition that performance of IEEE 802.16m can be perfectly kept not only, but also radio resource is optimized as much as possible. The figure 6 can be an example when the ratio (UL:DL) of TDD LTE is (1:1) and 1:1 of IEEE 802.16m under the condition of configuration 0 in 3GPP LTE TDD. In this kind of cases, any DL-UL intersected area doesn't exist anymore. Therefore it can be forecasted that the adjacent band based interference will be reduced.
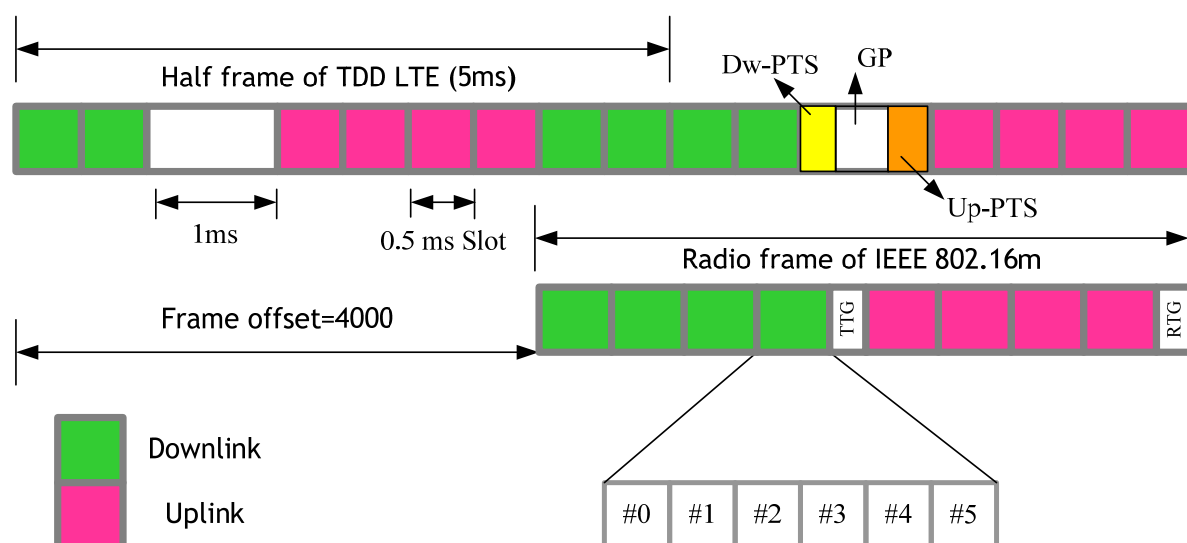

Figure 6: Example of solution result when ratio of UL:DL = 1:1 for both IEEE 802.16m and TDD LTE

And unfortunately in some cases this kind of coexistence / co-deployment can be guaranteed by using the proposed frame shifting based solutions, under the condition of a little cost of radio resource resulting in performance reduction. The figure 7 can be an example when the ratio (UL:DL) of TDD LTE is (1:1) and 3:5 of IEEE 802.16m under the condition of configuration 6 in 3GPP LTE TDD. It is clearly shown that, some DL-UL intersected area still exists. In order to completely mitigate this kind of interference, respective OFDMA symbols during this intersected area should be specially processed, such as being idle, or reducing its transmission power and so on.
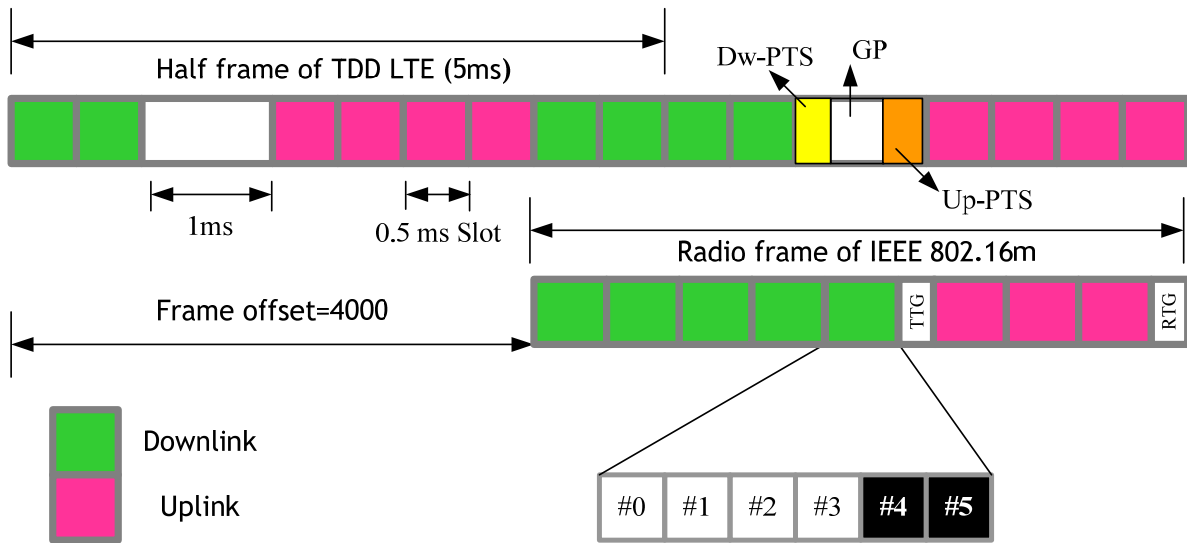
Figure 7: example of solution result when ratio of UL:DL = 1:1 for TDD LTE and 3:5 for IEEE 802.16m respectively

Proposed Text for SDD

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11.4.5.1 Coexistence with E-UTRA (LTE)

Coexistence between IEEE 802.16m and E-UTRA in TDD duplex scheme may be facilitated by inserting either idle symbols within the IEEE 802.16m frame or idle sub-frames. Applying a delay or offset between the beginnings of the IEEE 802.16m frame and the E-UTRA TDD frame may allow the time allocated to idle symbols or idle sub-frames to be minimized. Figures 11.4-6 demonstrate how coexistence between IEEE 802.16m and E-UTRA can be achieved to minimize the inter-system interference.
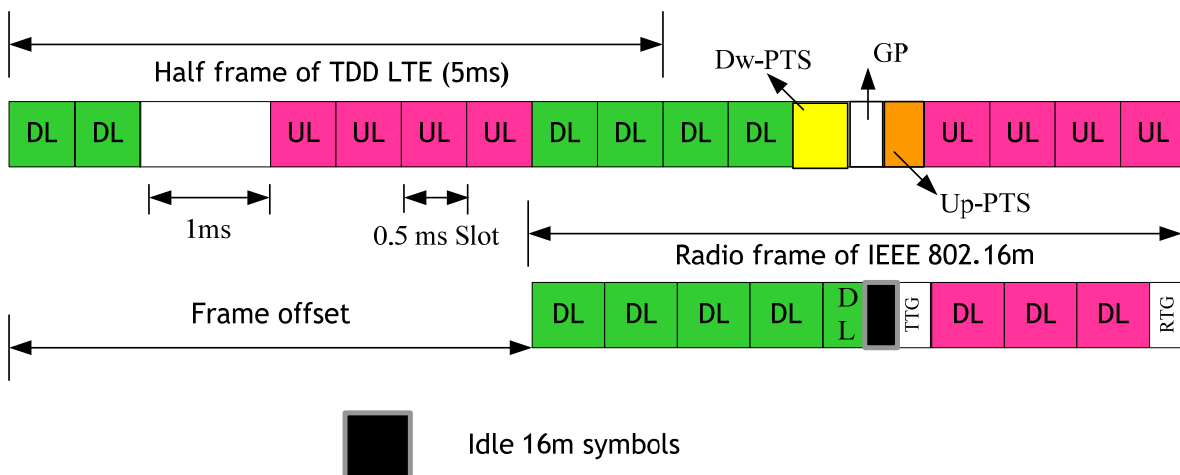

Figure 11.4-6: Alignment of IEEE 802.16m frame with E-UTRA frame in TDD mode

11.4.5.2 Coexistence with UTRA LCR-TDD (TD-SCDMA)

Coexistence between IEEE 802.16m and LCR-TDD may be facilitated by inserting either idle symbols within the IEEE 802.16m frame or idle sub-frames. Applying a delay or offset between the beginnings of the IEEE 802.16m frame and the LCR-TDD frame may allow the time allocated to idle symbols or idle sub-frames to be minimized. Figures 11.4-7 demonstrate how coexistence between IEEE 802.16m and LCR-TDD can be achieved to minimize the inter-system interference.
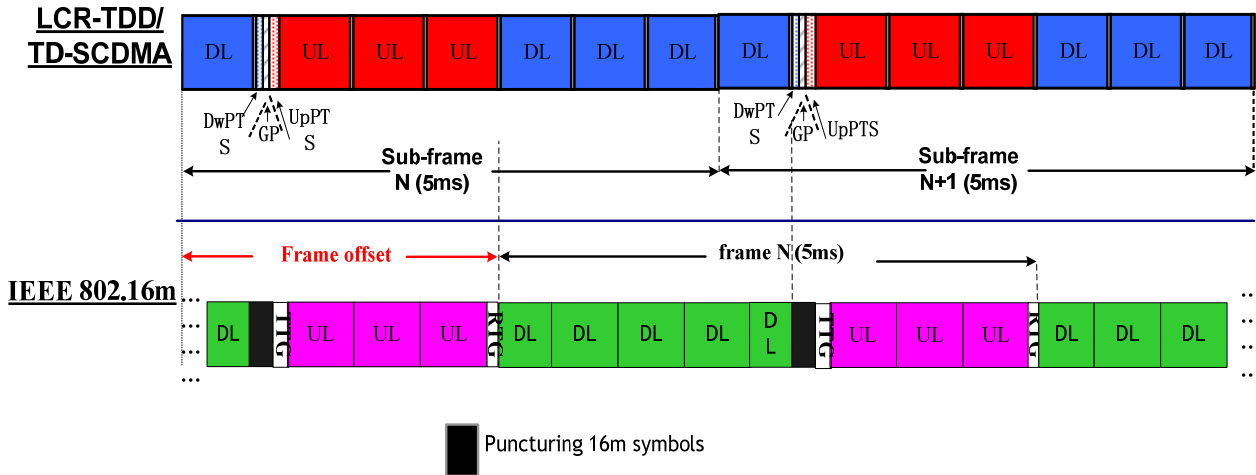

Figure 11.4-7: Alignment of IEEE 802.16m frame with UTRA LCR-TDD frame in TDD mode

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References

[1] IEEE C802.16m-07/002/r4, " IEEE 802.16m Requirements"

[2] IEEE C802.16m-08/003r1, "Draft IEEE 802.16m System Description Document"

[3] 3GPP LTE, TS36.211