

Agenda item: 6.2.3
Source: Huawei
Title: UL index in UL schedule grant for LTE TDD
Document for: Discussion and decision

1. Introduction

In TDD Adhoc meeting at Beijing the following decision on DL signalling has been made:

-Indication of UL subframe to which the resource assignment relates to by adding explicit signalling to the scheduling information

In 50 # meeting at Athens, “UL index” has been added into UL schedule grant, however, the corresponding signalling bit number for “UL index” is FFS.

In this contribution, signalling bit number for “UL index” in UL schedule grant for asymmetric UL/DL assignment is discussed for E-UTRA TDD.

2. The UL index in UL schedule grant for TDD

Because of the property of TDD duplex method that eNodeB/UE cannot transmit and receive simultaneously, only the uplink channel sounding results of the last and even earlier uplink period can be used for the uplink resource scheduling in current uplink period. It is possible for a UE to have multiple UL sub-frame allocations indicated in only one UL grant to save signaling overhead and these UL sub-frames have same resource assignment in frequency. To indicate all the possible combination of sub-frame allocations, more bits are needed in the grant. Table 1 shows the number of bits needed to indicate all possible combinations of the UL sub-frames for different UL/DL ratio.

Table 1 All possible combinations of the UL sub-frames for different UL/DL ratio

	<i>Ratio of UL/DL(6:1)</i>						<i>Ratio of UL/DL(5:2)</i>					<i>Ratio of UL/DL(4:3)</i>			
<i>Number of UL sub-frames indicated per UL grant</i>	1	2	3	4	5	6	1	2	3	4	5	1	2	3	4
<i>Number of Combinationr</i>	6	15	20	15	6	1	5	10	10	5	1	4	6	4	1
<i>Number of bits for all status indication</i>	6						5					4			

Besides the issue of how many UL sub-frame allocations indicated in one UL grant, another point to be considered is the downlink ability to feedback ACK/NAK where QPSK is used in downlink which can carry at most 2 bits. If using the same way as FDD linking ACK/NAK resource to uplink grant index one ACK/NAK resource is available as only one uplink grant is used to assign the resource over multiple uplink sub-frames.

Considering the number of bits required for each grant, overhead saving and available ACK/NAK resource, it is a good choice to assign not more than 2 sub-frame allocations in one UL grant.

In this contribution, two options for adding sub-frame index bits in uplink grant are suggested as described below.

Option 1 4 bits for sub-frame index are used for indicating single sub-frame and various combinations of two sub-frame allocation.

One example of this option for LTE TDD with frame structure type 2 is shown in table 2.

Table 2 The associated UL sub-frames in each UL grant

Sub-frame index	Ratio of UL/DL(6:1)*		Ratio of UL/DL(5:2)		Ratio of UL/DL(4:3)	
	TS0	DL	TS0,TS6	DL	TS0,TS5,TS6	DL
	TS1~TS6	UL	TS1~TS5	UL	TS1~TS4	UL
0000	TS1		TS1		TS1	
0001	TS2		TS2		TS2	
0010	TS3		TS3		TS3	
0011	TS4		TS4		TS4	
0100	TS5		TS5		TS1,TS2	
0101	TS6		TS1,TS2		TS1,TS3	
0110	TS1,TS2		TS1,TS3		TS1,TS4	
0111	TS1,TS3		TS1,TS4		TS2,TS3	
1000	TS1,TS4		TS1,TS5		TS2,TS4	
1001	TS2,TS3		TS2,TS3		TS3,TS4	
1010	TS2,TS4		TS2,TS4		Reserved	
1011	TS3,TS4		TS2,TS5		Reserved	
1100	TS3,TS5		TS3,TS4		Reserved	
1101	TS4,TS5		TS3,TS5		Reserved	
1110	TS4,TS6		Reserved		Reserved	
1111	TS5,TS6		Reserved		Reserved	

* For the ratio of UL/DL(6:1),10 of 15 combination of 2 UL sub-frames indicated per UL grant are selected.

Option 2 If only consecutive sub-frame assignment is supported, 3 bits for sub-frame index are enough.

One example of this option for LTE TDD with frame structure type 2 is shown in table 3.

Table 3 The associated UL sub-frames in each UL grant

Sub-frame index	Ratio of UL/DL(6:1)		Ratio of UL/DL(5:2)		Ratio of UL/DL(4:3)	
	TS0	DL	TS0,TS6	DL	TS0,TS5,TS6	DL

	TS1~TS6 UL	TS1~TS5 UL	TS1~TS4 UL
000	TS1	TS1	TS1
001	TS2	TS2	TS2
010	TS3	TS3	TS3
011	TS4	TS4	TS4
100	TS5	TS5	TS1,TS2
101	TS6	TS1,TS2	TS2,TS3
110	TS1,TS2	TS3,TS4	TS3,TS4
111	TS2,TS3	TS4,TS5	Reserved

It is noted that not all the combinations are supported for the 6: 1 ratio of UL/DL. In real applications, the 6:1 setting is rarely deployed because with only one DL sub-frame there is nearly no rooms for downlink data transmission besides control signaling, BCH and SCH. Hence the design is optimal for 5:2 and 4:3 case.

With these tables we can conclude that when there are more UL sub-frames than DL sub-frames, 3 to 4 bits should be added in UL schedule grant signaling to indicate the associated one or two UL sub-frames.

[1] and [2] propose to use a bitmap-type approach for “UL index” in UL schedule grant, and it is obvious to achieve the maximum multiplexing flexibility, which also increase the signaling overhead compare to our proposed approach. However, bitmap-type approach show that more than 2 sub-frame allocations in one UL grant will cause a new question that it is very difficult to use the same way as FDD linking ACK/NAK resource to uplink grant index.

3. Summary

In this contribution, signaling bit number of “UL index” in UL schedule grant for asymmetric UL/DL assignment for E-UTRA TDD is discussed. We propose that:

- 3 to 4 bits for “UL index” can be added in UL schedule grant for asymmetric UL/DL assignment for E-UTRA TDD which could support up to two UL sub-frame allocations in one UL grant.
- Use either options 1 or 2 to address UEs in asymmetric UL sub-frames.

References

- [1] R1-073646, “Multi-TTI Uplink Grants for TDD(FS1+FS2)”, Nokia, Nokia Siemens Networks
[2] R1-073776, “On the TDD UL Grant Channel”, IPWireless, NextWave Wireless