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Re:	IEEE 802.16m-08/052, Call for Comments on Project 802.16m System Description Document (SDD) (2008-12-12)
Abstract	This contribution proposes resource blocks for DL and UL Hybrid ARQ on 16m frame structure
Purpose	To be discussed and approved by TGm.
Notice	
Release	
Patent Policy	

Resource Blocks Allocation for DL and UL Hybrid ARQ

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1. Introduction

This contribution focuses on defining the resource block for hybrid-ARQ (HARQ) based on the new frame structure in IEEE802.16m SDD [1]. From the basic frame structure defined in 802.16m, there exist two types of subframes: 1) the regular subframes with six OFDM symbols and 2) the irregular subframes with seven OFDM symbols. The co-existence of regular and irregular subframe and the resource unit defined based on such subframe structures make the HARQ allocation more complicate than that in the legacy system which consists of all regular minimum resource units (slots). Furthermore, the reduced transmission time interval (TTI) in IEEE802.16m provides the flexibility to minimize the HARQ process delay and round trip time (RTT) within the new frame structure.

On the other hand, IEEE802.16m [1] has adopted the asynchronous hybrid ARQ for the downlink (DL) transmission. The retransmissions may occur at any time. For asynchronous hybrid ARQ in the DL, IEEE 802.16m uses an adaptive HARQ scheme, in which the resource allocation and transmission format including the modulation and coding rate for the HARQ retransmissions can be different from the initial transmission. For the uplink (UL) transmission, IEEE802.16m has adopted the synchronous hybrid ARQ, so the retransmissions are restricted to occur at known time instants.

Due to the existence of irregular subframes and the physical resource units (PRU) with different sizes, some disadvantages arise for the resource allocation of hybrid ARQ schemes in the DL and UL in TDD such as additional signaling overhead, the allocation mismatch problem for synchronous UL HARQ and requirement of complex Transmission Format Table (including encoding packet size, coding and modulation). Thus the efficient design on the resource block for hybrid ARQ processes is then important. In this proposal, we investigate the frame structures and resource unit definition in IEEE 802.16m SDD [1], and provide a solution on the resource block for the hybrid ARQ for the DL and UL in TDD duplex scheme. We propose the resource block allocation for hybrid ARQ processes in both DL and UL. and introduce additional constraint on some cases of the UL hybrid ARQ as the amendments of IEEE802.16m SDD.

2. Overview of Frame Structure in IEEE 802.16m

The IEEE 802.16m basic frame structure is defined as follows [1]. Each 20 ms superframe is divided into four equal-sized 5 ms radio frames. Each 5ms radio frame is further divided into 8 subframes. Based on the bandwidth and the length of cyclic prefix (CP), there are two types of subframes: 1) the type-1 subframe which consists of six OFDMA symbols and 2) the type-2 subframe that consists of seven OFDMA symbols. In both subframe types, some of symbols may be idle symbols.

In this proposal, we focus on TDD duplex scheme. An example frame structure with DL/UL ratio 5:3 in TDD duplex is shown in Fig. 1. The CP size is 1/8 Tu, where Tu is the OFDM symbol duration. Currently the frame structure in IEEE 802.16m SDD supports two cyclic prefix (CP) sizes, i.e., 1/8 Tu and 1/16 Tu.

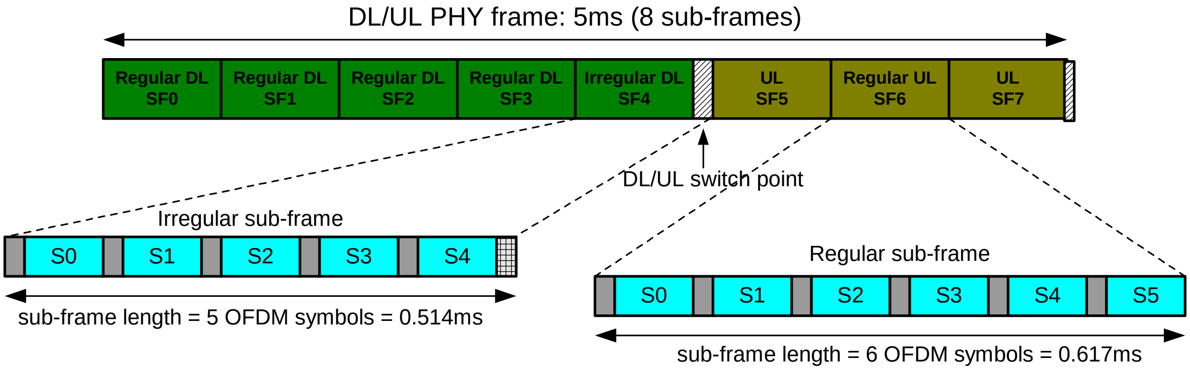

Figure 1: Regular and irregular subframes in TDD duplex scheme (CP=1/8 Tu)

For 1/8 Tu CP size, 48 OFDM symbols are formed. Each subframe consists of evenly 6 OFDM symbols. However, due to TDD duplex, TTG and RTG have to be inserted when the transmission switches between DL and UL. We can see from Fig. 1, to satisfy the 5m constraint in one radio frame, the last symbol in the DL portion (the last symbol in the fifth DL subframe) is set to be idle for TTG. Therefore, the effective number of OFDM symbols in that subframe is only 5. In the following text, we also refer the subframe with less effective number of OFDM symbols to as the irregular subframe.

For some other CP size or DL/UL ratio, e.g., 1/16 Tu CP size, we may have subframes with 7 OFDM symbols. Table 1 summarizes the number of OFDM symbols for the DL and UL with different DL/UL ratio (from 1:7 to 7:1 with one subframe increasing step in the DL portion) for both 1/8 Tu and 1/16 CP sizes.

	CP 1/8 Tu		CP 1/16 Tu			
	DL	UL	DL	UL	TTG(μs)	RTG(μs)
DL:UL=1:7	5(5)	42	5(5)	44(7,7)	134.2857	105.7143
DL:UL=2:6	11(5)	36	12	38(7,7)	71.4286	71.4286
DL:UL=3:5	17(5)	30	18	32(7,7)	105.7143	37.1429
DL:UL=4:4	23(5)	24	24	25(7)	140.0000	100.000
DL:UL=5:3	29(5)	18	31(7)	19(7)	77.1429	65.7143
DL:UL=6:2	35(5)	12	37(7)	13(7)	111.4286	31.4286
DL:UL=7:1	41(5)	6	43(7)	6	145.7143	94.2857

Table 1. Number of OFDM symbols in the DL and UL portions in TDD duplex scheme (for CP=1/8 Tu, TTG and RTG are always 102.8571 μs and 62.86 μs, respectively, as in [1]).

In Table 1, TTG and RTG for 1/16 Tu CP are calculated based on the alignment with IEEE 802.16e for DL and UL transmissions. The values may be different if other schemes are considered, e.g. [2]. The numbers in the parentheses are the numbers of OFDM symbols in the irregular subframe(s), i.e., (5) represent that there is a subframe with 5 OFDM symbols in this DL or UL portion, and (7,7) represents that there are two subframes with 7 OFDM symbols. We can see for 1/8 Tu CP, there is only one irregular subframe in the DL portion. However, for 1/16 Tu CP, there are irregular subframes in both DL and UL with 5 or 7 OFDM symbols

3. Physical Structure in IEEE 802.16m

In IEEE 802.16m SDD [1], the resource block for transmission is defined as resource unit. A physical resource unit (PRU) is the basic physical unit for resource allocation that comprises P_{sc} consecutive subcarrieres by N_{sym} consecutive OFDMA symbols where P_{sc}=18, and the value of N_{sym} depends on the number of OFDM symbols in the subframe. Therefore, the PRU is a rectangular region aligning with the subframe boundary. For different types of subframes with different number of effective OFDM symbols, we have PRU with sizes of 18*5, 18*6, or 18*7 symbols. A logical resource unit (LRU) is the basic logical unit for resource allocations. The size of LRU, including the logical distributed resource unit (LDRU) and the logical localized resource unit (LLRU), is the same as that of the PRU.

Similarly for the UL, a PRU is defined as Psc subcarriers by Nsym consecutive OFDMA symbols, where Psc=18 and Nsym is the number of OFDMA symbols depending on the subframe type. A logical resource unit (LRU) is the basic logical unit for data transmission in the UL. The size of LRU, including the logical distributed resource unit (LDRU) and the logical localized resource unit (LLRU), is the same as that of the PRU. For LDRU, the minimum unit for forming the LDRU is a tile of a size 6*Nsym, where Nsym could be 5,6 or 7

Unlike the uniform resource unit in legacy system, the PRU with different sizes in IEEE806.16m incurs additional signaling overhead for HARQ burst profiles.

4. Resource Block for HARQ

4.1 Resource Block for UL HARQ

IEEE802.16m [1] has adopted the synchronous hybrid ARQ for the UL so that the retransmissions are restricted to occur at known time instants. For UL synchronous hybrid ARQ, the resource block can be changed during the retransmission. Therefore, for UL hybrid ARQ, the transmission format for retransmission is exactly the same as the original transmission. Although the resource block can be changed, the size and shape of resource block should not change. Only the allocation of the resource block can be rescheduled. Due to irregular subframe existing in IEEE 802.16m frame structure and definition of Nsym, there can be an allocation mismatch problem for some cases of UL hybrid ARQ.

As shown in Table 1, for 1/8 Tu CP size, the subframes in the UL portion for all DL/UL ratios are regular. Therefore, with any definition of LRU aligning with the subframe boundary, the synchronous hybrid ARQ for the UL can be satisfied.

However for 1/16 Tu CP size and a certain DL/UL ratio in TDD duplex scheme, there could be a problem for synchronous non-adaptive UL hybrid ARQ if Nsym equals number of OFDM symbols in a subframe. For example, Figure 2 illustrate a dysfunctional timing diagram for non-adaptive synchronous UL HARQ with DL:UL=2:6 for 8 hybrid ARQ processes. From Table 1, we know that there are two irregular subframes with 7 OFDMA symbols each. We assume that the fifth and the sixth subframes are the irregular ones in a 5ms frame. As shown in Fig. 2, the UL subframe 5 is an irregular UL frame. For HARQ process 3, the first transmission is in the UL subframe 3 which is a regular subframe. Based on the non-adaptive synchronous HARQ protocol in [1], it is retransmitted at UL subframe 5. However, since the UL subframe 5 is irregular, the retransmission has to be redefined to another subframe. The UL subframe 5 should be defined for a new HARQ process. Similar mismatching problem exists in HARQ process 4, 5, and 6.

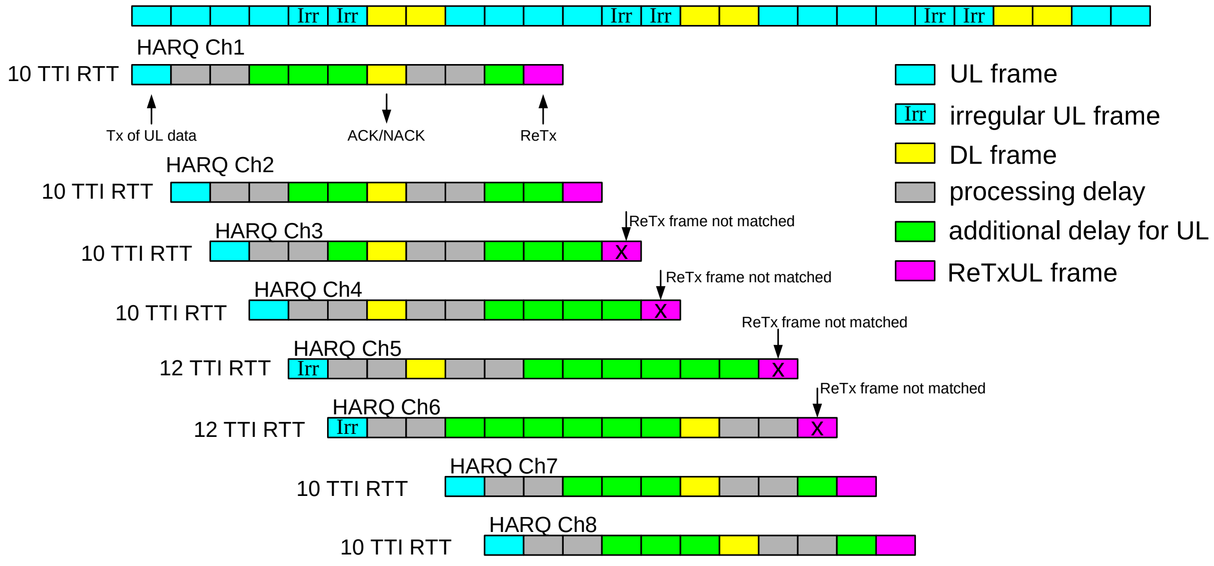

Figure 2: Mismatch problem in non-adaptive synchronous UL HARQ with irregular UL subframe (DL:UL=2:6)

Therefore, for non-adaptive synchronous UL HARQ, to solve such mismatching problem, we propose the following two options to restrict the UL subframes for UL HARQ usage as follows.

Option 1:

If the irregular subframe has more than 6 OFDM symbols, we treat this irregular subframe as a regular subframe by allocating only the first 6 OFDM symbols for HARQ process with the Nsym=6 in LRU. If the irregular subframe has less than 6 OFDM symbols, we do not allocate HARQ process to this irregular subframe.

Option 2:

If the irregular subframe has more than 6 OFDM symbols, we treat this irregular subframe as a regular subframe by allocating the first 6 OFDM symbols for HARQ process with the Nsym=6 in LRU. We select some OFDM symbols in the first 6 OFDM symbols and send them using the last OFDM symbol. If the original transmission in a HARQ process occupies a LRU consists of an irregular subframe, when mismatch happens at the retransmission, the data symbols transmitted at the first 6 OFDM symbols are resent. If the original transmission does not have a LRU consists of an irregular subframe, when mismatch happens at the retransmission, the selected symbols are repeated for the last OFDM symbol. How to select data symbols for repetition is FFS. Similarly, if the irregular subframe has less than 6 OFDM symbols, we also treat this irregular subframe as a regular subframe but transmit the data through this subframe with some data symbols punctured. How to puncture the data symbol is FFS.

Note that for although there is no subframe with 5 or less OFDM symbols in Table 1, it may happen for other CP size, such as long CP frame structure as in [3].

4.2 Resource Block for DL HARQ

For DL transmission, we can see from Table 1, for 1/8 Tu CP size, although all the subframes have 6 OFDM symbols each, the last one in the DL portion has one OFDM symbol idle for TTG. Therefore, the effective number of symbol is only 5. Also as shown in Table 1, for 1/16 Tu CP size there are some irregular subframes with 7 OFDM symbols each. Based on the definition of PRU in SDD [1], the size of PRU is Psc*Nsym, where Psc=18, Nsym=6 or 7. For the subframe with 5 effective OFDM symbols, we have actually Nsym=5. Although in the DL, the asynchronous adaptive hybrid ARQ has been adopted in IEEE 802.16m [1] so that resource block and transmission format can be changed to adapt the size of subframe in the retransmission, non-uniform resource unit makes scheduling difficult for the (re)transmissions in IR HARQ. Therefore, for DL HARQ, we propose that the resource block allocation for HARQ is also based on regular subframe structure with 6 OFDM symbols.

For DL HARQ, a transmission format can be built based on the encoded packet size and number of allocated PRU, the above proposed scheme substantially facilitate the transmission format design and the determination of modulation order to be used.

Exclude the pilot symbols, total 96 symbols can be allocated in every PRU. The modulation can be decided based on the following equation.

$$MPR = \frac{N_{EP}}{96 \cdot N_{PDU}}$$

where N_{EP} denotes the encoding packet size, N_{PDU} denotes number of PDU.

- If $0 < MPR < 1.5$, then QPSK is used.

- If $1.5 \le MPR < 3.0$, then 16QAM is used.

- If $3.0 \le MPR < 5.4$, then 64QAM is used.

Similar to Table 505 in [4], a Table can be built to obtain the transmission format and modulation for the DL HARQ. The detailed table can be determined after the channel coding is specified, e.g. lowest code rate and maximum block size.

To solve the irregular subframe problem for DL HARQ, we propose the following two options. The exact option to select is FFS.

Option 1:

If the irregular subframe has more than 6 OFDM symbols, we treat this irregular subframe as a regular subframe by allocating only the first 6 OFDM symbols for HARQ process with the Nsym=6 in LRU. If the irregular subframe has less than 6 OFDM symbols, we do not allocate HARQ process to this irregular subframe.

Option 2:

If the irregular subframe has more than 6 OFDM symbols, we treat this irregular subframe as a regular subframe by allocating the first 6 OFDM symbols for HARQ process with the Nsym=6 in LRU. We select some OFDM symbols in the first 6 OFDM symbols and send them using the last OFDM symbol. How to select data symbols for repetition is FFS. Similarly, if the irregular subframe has less than 6 OFDM symbols, we also treat this irregular subframe as a regular subframe but transmit the data through this subframe with some data symbols punctured. How to puncture the data symbols is FFS.

5. Conclusion

We would like to propose the following text proposal inserted to **IEEE 802.16m SDD.**

================================ *Start of Proposed Text*===============================

11.13.2.7 Resource block allocation for HARQ.

The resource block allocation for HARQ is always based on the regular type-1 subframe structure with 6 OFDM symbols.

The HARQ (re)transmission allocated with a resource unit in a type-2 irregular subframe with 7 OFDM symbols can either occupy only 6 OFDM symbols or occupy 6 OFDM symbols but repeat some data symbols in the additional OFDM symbol. The exact choice is FFS.

An HARQ process can either avoid a resource unit in a type-1 subframe with 5 effective OFDM symbols or use it with some data symbols punctured. The exact choice is FFS.

================================ *End of Proposed Text*============================

5. References

[1] C802.16-08/003r5, “SDD document, The Draft IEEE 802.16m System Description Document”.

[2] C802.16m-08/474r3, “Frame structure with multiple sub-frame sizes”.

[3] C802.16m-08/1130r2 “Long CP frame structure design enabling time-multiplexed unicast and E-MBS”.

[4] IEEE Standard 802.16 Working Group, Part 16: Air Interface for Broadband Wireless Access Systems, P802.16Rev2/D3, Feb. 2008.

[5] C802.16m-08/334r1, “Hybrid ARQ Protocols and Signaling for DL and UL Transmissions”.