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Definitions for H-FDD mode in OFDMA

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1.   Motivation

The definition of H-FDD mode for OFDMA-PHY is partial and doesn't enable correct operation. In addition, the H-FDD scheme is complicated to implement and inefficient when applied to OFDMA. We propose a set of rules that define the missing details and simplify operation.

2.   Details

2.1.   Problems with current standard

2.1.1.   Missing UL-subframe duration

It is not specified whether in FDD the UL-subframe terminates at the end of the frame or may continue to the next frame (as may be implied by figure 49 in section 6.3.7.5 (Map relevance and synchronization). If the UL-subframe may continue to the next frame, then the length of the UL-subframe must be specified (it is not; in TDD the SS can assume the UL-subframe terminates at the end of the frame).

2.1.2.   Unspecified definitions for contention and broadcast areas

According to 8.4.4.2 the BS should not allocate a DL transmission that collides with a scheduled UL allocation, but the following details are not specified:

(a) Is a contention (ranging/BW-req) allocation considered an UL allocation for all users ? Since SS initiate initial/periodic ranging transmissions, should the BS assume that any SS may potentially transmit and refrain from allocating DL for it (if it is H-FDD) ? Or is it assumed that a transmitting SS will lose the DL transmission (with small effect on performance, assuming ranging is rare). Note that in this case the SS cannot postpone the contention transmission when it collides with a DL allocation, since DL allocations may be broadcast or without CID.

(b) Are the preambles and/or the MAPs considered a "DL transmission" for this matter ? I.e. should H-FDD users always assume they will be allowed to receive the preamble & MAPs ? From figure 44 (6.3.7.1) it is implied that an H-FDD user will not be required to transmit during the preamble and the broadcast part of the DL-subframe

2.1.3.   Inefficiency due to OFDMA transmission scheme

For other PHYs in 802.16 the multi-user access method is TDMA. Therefore, each SS will receive it's DL data for small time portion frame, and transmit UL data in small portion of the frame time. The H-FDD scheme is based on this fact, relying on the BS scheduler to interleave the UL and DL portions of each SS in such a way that efficiency will be maintained.

In OFDMA, there is multiple access in frequency and time division, so that each SS usually receives and transmits in large portions of the frame time. Especially in the UL, the allocations are made in time-first order such that almost every UL transmission occupies all the UL-subframe (/zone) duration. With this multiple access structure the notion of transmitting part of the time and receiving part of the time during the same frame loses its value, and only poses complications.

2.1.4. Reliance on FDD subscribers

The current definition of H-FDD relies on the existence of non-H-FDD subscribers in order to make use of the bandwidth that cannot be used by H-FDD subscribers (for example, the UL portions overlapping the preamble, and the DL portions overlapping the ranging allocations).

However, since no single SS uses the entire channel bandwidth, in actual deployments it does not make sense to install FDD subscribers which are more expensive than H-FDD subscribers. So an efficient FDD/H-FDD scheme shouldn't assume that FDD subscribers necessarily exist.

2.2. Proposed solution

The idea behind the proposed solution is to achieve similar performance and system-like behavior to TDD but, using 1/2 the frame duration. Example: TDD with 5ms frame w.r.t an H-FDD SS in FDD with 2.5ms frame.

2.2.1. Proposed set of rules for H-FDD

In order to achieve this, we define a set of rules that define the missing details and simplify operation:

(a) If an H-FDD SS transmits any time in a given frame (even part of the time), it is not required to receive during that frame or any frame that overlaps with the transmission, including the allowance for SSRTG,SSTTG and RTD. This includes the preamble and the broadcast area that contains the FCH, DL and UL MAPs, DCD, UCD, etc. For this matter, transmission means a data allocation, fast feedback transmission, and CDMA transmissions.

(b) UL map relevance:
     i.   Minimum value: Allocation Start Time$>= 3\cdot T_f$
     ii.   Maximum value: Allocation Start Time $< 4 \cdot T_f$
     iii. $T_{proc} = 2\cdot$Frame

(c) The BS shall not allocate any UL allocations for an H-FDD SS in any two contiguous frames (UL after UL). For this matter, allocations include UL data, fast feedback transmission, and CDMA transmissions.

(d) When the BS allocates a broadcast periodic ranging / BW request allocation the consequence may be that every H-FDD subscriber may potentially transmit contention transmission and as a result will not receive the entire frame. In order to mitigate this problem we propose to use multicast periodic ranging/BW-request allocation. This mechanism is implicit in the standard, and should become explicit.

(e) For initial ranging the BS may use a broadcast allocation (since these users are not required to receive).

2.2.2.   Usage Example

In the following example we show how, under the above rules, the scheduler can obtain the same system behavior and efficiency of a TDD system (with equal UL and DL portions), with the same processing requirements on the SS.

The H-FDD system will use half the frame duration of the respective TDD system. A possible way to allocate UL and DL bandwidth, is such that each H-FDD subscriber may receive on each even frame and may transmit on odd frames, or vise versa. This way two H-FDD frames (DL frame + UL frame) are analogous to one TDD frame (DL+UL). Part of the users will receive on even frames and transmit on odd frames and the other part will receive on odd frames and transmit on even frames.

The BS will align the UL and DL subframes, so that the when transmitting the SS will not receive only a single downlink frame.

Periodic ranging and bandwidth request allocations can be made in either of two ways:
1. Using a broadcast allocation every N frames – in this case this frame should not include any DL information for H-FDD users.
2. Splitting the SS to two multicast groups, and using a multicast ranging allocation addressed only to one group of the users. The ranging allocation will be in the frame designated for UL transmission for the users in this group.

Note that the BS has the flexibility of breaking the two-frame structure (DL-UL) for various purposes, such as transmission of broadcast bursts to all subscribers, or transmission of downlink information only.

The UL map relevance is 3 frames ahead, which is similar to UL map relevance of 1 frame ahead in a TDD system with a double frame duration (see figure below).

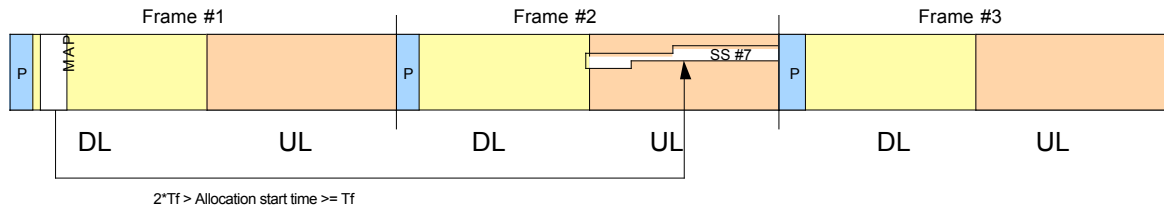The following figure illustrates the solution:

FDD
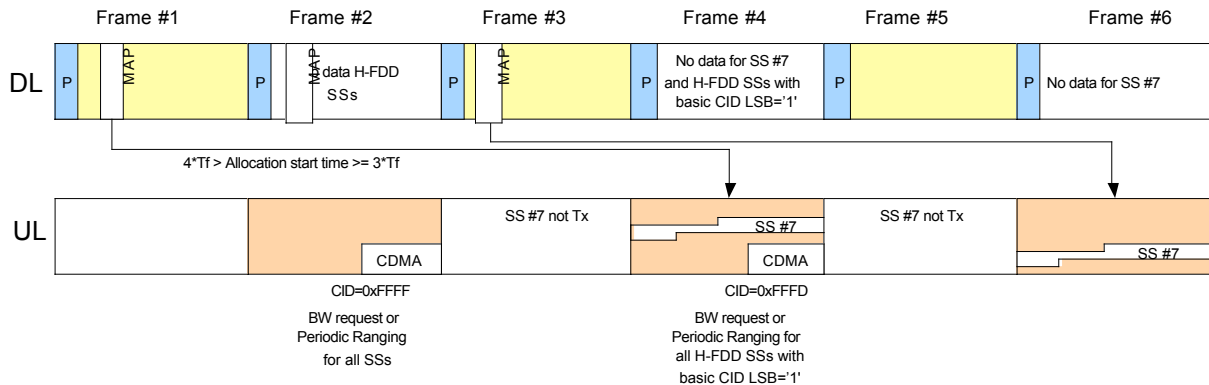
TDD

Figure 1 – example of efficient H-FDD operation

Note: the number of symbols in the UL shall be derived according to comment C80216main4_12.

2.3.   **Changes with respect to C80216maint-04_11**

- Method to allocate ranging to groups – was changed from special CIDs dividing the users in a fixed way (even and odd basic CIDs) to multicast groups. The reason – fixed division is sensitive to the statistics of each group (i.e. what happens if all heavy traffic is from odd CIDs, or all even-CIDs leave the cell).

3.   Changes summary

6.3.7.1 FDD
[add the following section under 6.3.7.1]

6.3.7.1.1 H-FDD mode in OFDMA
For OFDMA PHY, when the BS allocates uplink bandwidth for a H-FDD SS, then the SS is not required to receive any DL frame which fully or partially overlaps the transmission at the SS antenna interface, including a period of SSRTG before and SSTTG after the transmission. For this matter, transmission means a data allocation, fast feedback transmission allocation, and CDMA transmissions.

The BS shall not allocate any UL transmissions for an H-FDD SS in two consecutive UL-subframes. For this matter, allocations include UL data, fast feedback transmission, and allocation of contention slots that may be used by the SS.

6.3.7.5.4 WirelessMAN-OFDMA PHY
[Make the following change]
For TDD, the Allocation Start Time shall be subject to the following limitations:
— Minimum value: Allocation Start Time >= *Tf*
— Maximum value: Allocation Start Time < 2 * *Tf*

For H-FDD systems, the Allocation Start Time shall be subject to the following limitations:
— Minimum value: Allocation Start Time >= 3*Tf
— Maximum value: Allocation Start Time < 4 * Tf

Operation of FDD mode is intended for short frame durations (≤ 10ms).
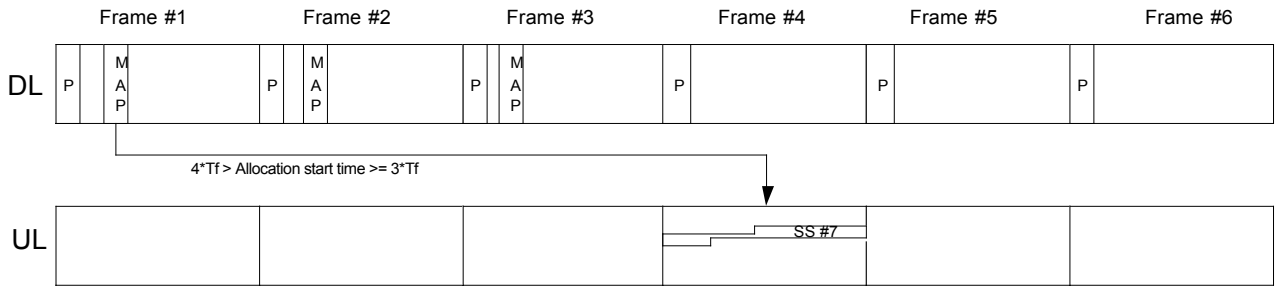
[add figure 49a]

Figure 49a – MAP relevance for H-FDD in OFDMA PHY

8.4.5.4 UL-MAP IE format
[Add the following paragraph starting from p. 534 line 11]
For UIUC=12 allocations may include broadcast or multicast polling CID. In cast of multicast polling CID the allocation will be used only by members of the multicast polling group and ignored by other SS.

10.1 Global values
[Make the following change in table 340 (p.642, line 10):]

BS, SS	Tproc	Time provided between arrival of the last bit of a UL-MAP at an SS and effectiveness of that map	SC: 200 µs OFDM: 1 ms OFDMA: 10 OFDMA Symbols For TDD: T_f (frame duration), for FDD: 2·T_f

10.3.4.1 Uplink Allocation Start Time
[Make the following change]
Unit of Allocation Start Time shall be PSs from the start of the downlink frame in which the UL-MAP message occurred. The minimum value specified for this parameter shall correspond to the value of T_{proc} specified in Table 340 10 OFDMA symbols