Project	**IEEE 802.16 Broadband Wireless Access Working Group <**http://ieee802.org/16**>**
Title	FDD and H-FDD frame structure for IEEE 802.16j Multihop Relay Networks
Date Submitted	**2008-09-15**
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Re:	Frame structure proposals for FDD and H-FDD support in 16j MR networks
Abstract	This contribution proposes text amendments to enable FDD mode in 16j multihop relay networks.
Purpose	Text proposal for 802.16j relay frame structure for FDD mode
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FDD and H-FDD mode for IEEE 802.16j Multihop Relay Networks

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Introduction

IEEE 802.16j/D6 supports only TDD frame structure, and therefore, only the TDD mode of operation. However, the IEEE 802.16e/Rev2 supports FDD operation. Rev2 support half-duplex FDD (H-FDD) and full duplex FDD capable mobiles. The FDD and H-FDD operation has also been included as additional features in Wimax Profile Release 1.5. Therefore, relay support for FDD operation is very desirable such that the coverage and other performance enhancement of relay systems canbe extended to the FDD based 16e systems as well.

To that end, in this contribution, we discuss the FDD and H-FDD support for multihop networks and propose text amendments to extend the use of relays to the FDD and H-FDD mode of operation.

Single- and Dual-radio Relay Stations in TDD and FDD mode

16j defines two relay station types according to the number of carriers they can support during relaying

— Single radio relay: A relay that uses the same carrier frequency as the MR-BS DL/UL carrier for its downlink and UL transmissions, e.g., the MR-BS transmits to the relay at frequency f1 in interval T1, and the relay forwards the signals to its subordinate stations at f1 in interval T2. T1 and T2 shall not have any overlapping period.

— Dual–radio relay: A relay that uses a different frequency from the MR-BS DL/UL carrier for its downlink and uplink transmissions, e.g., the MR-BS transmits to the relay at frequency f1, and the relay forwards the signals at f2 to its subordinate stations. The relay station can operate in full duplex mode since it can receive from its super-ordinate station at carrier-f1 while transmitting to its subordinate stations at f2.

Note that the above definitions assume TDD operation, that is, the same frequency is being used for both DL and UL communication.

For FDD operation, DL and UL frequencies are different from each other. An MS/SS that has full-duplex capability may transmit and receive at the same time in FDD mode. For half-duplex MS/SS, one can also seek FDD mode in which case, the MS/SS uses two non-overlapping intervals for DL and UL, though, still using two different carriers, one for DL, and one for UL. Note that the splitting of the frame in two different intervals are with regard to MS transmissions. From BS perspective, whole frame is used as DL and UL at the same time. That is, full-duplex mobile station can be allocated resources from all H-FDD resources.

An RS can also be designed to operate in FDD mode. For this case, we have two different options for the RSs as summarized below:

— RS uses the same carrier for its DL (UL) transmission as its superordinate station does for its DL (UL). This option requires 2 carrier frequencies, and the frame structure may have to be split into access and relay zones. Figure 1 presents the DL/UL transmission in FDD mode where relaying operation in time division fashion

and the relay is half-duplex (e.g., it does not receive and transmit simultaneously at the same carrier), while Figure 2 presents the DL/UL transmissions in FDD mode with full-duplex relay (e.g., it receives/transmits simultaneously at the same carrier frequency).

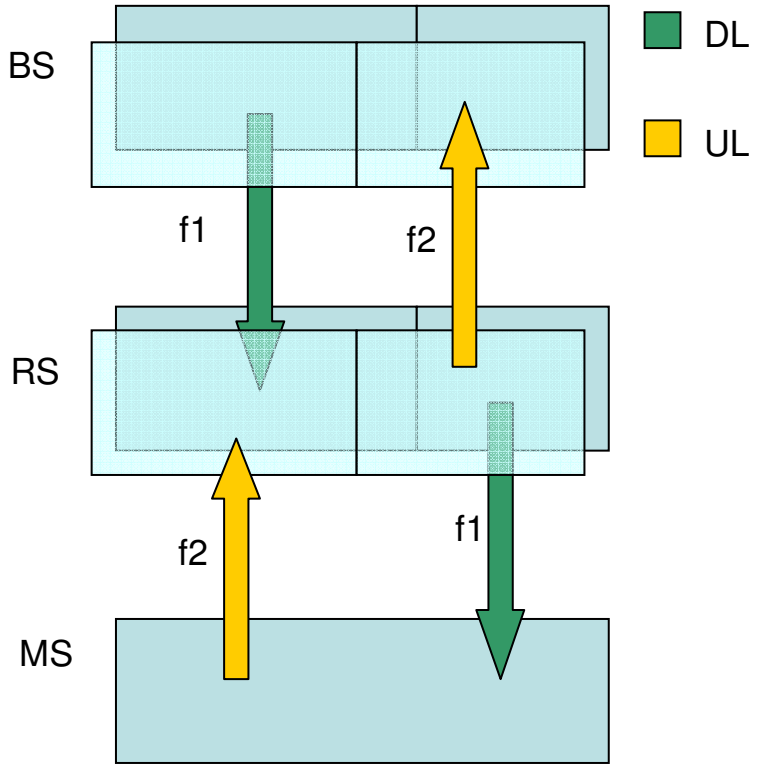

Figure 1 DL and UL transmission in FDD mode with half-duplex FDD relay. Each hop employs the same carrier pairs in FDD.

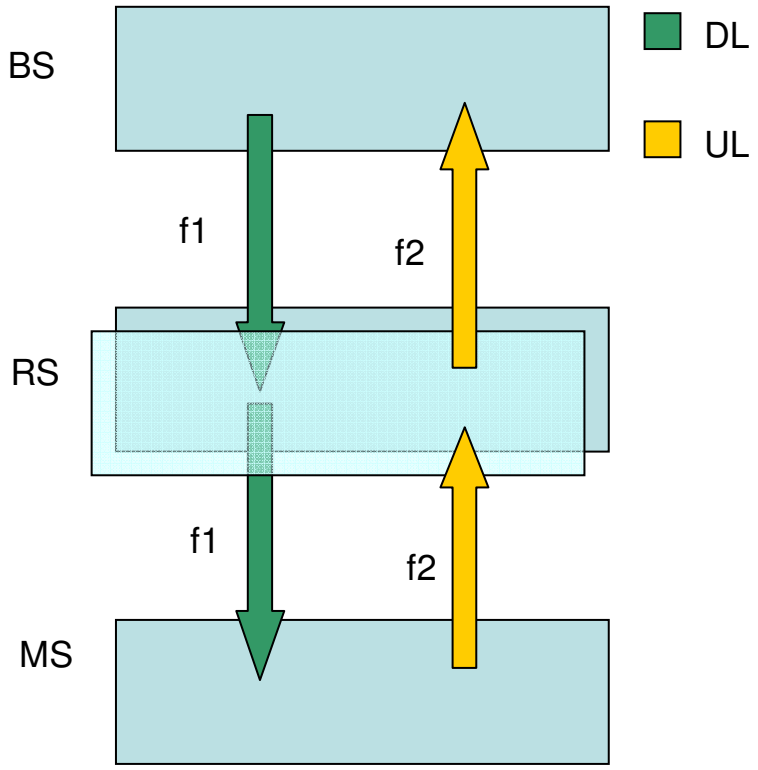

Figure 2 DL and UL transmission in FDD mode with full-duplex FDD relay. Each hop employs the same carrier pairs in FDD.

— RS uses a different DL (UL) frequency from the DL (UL) frequency of its super ordinate station. Note that this option requires 4 carriers (2 for odd hops and 2 for even hops). Figure 3 depicts this case.

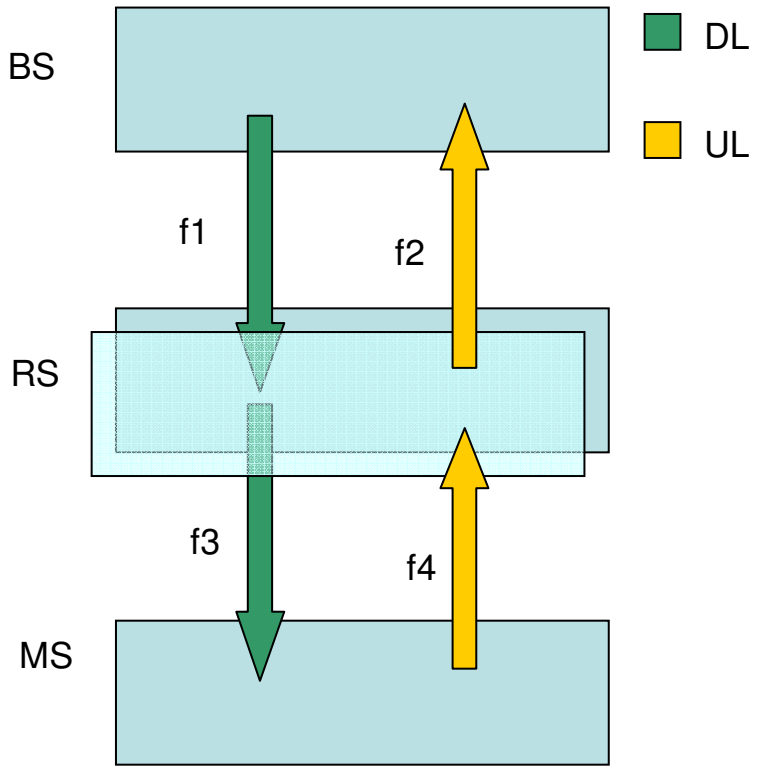

Figure 3 DL and UL transmission in FDD mode with full-duplex FDD relay. Each hop employs a different set of carrier pairs in FDD.

The cases depicted in Figure 2 and Figure 3 are similar to each other except that the relay that can operate according to Figure 2 may require more complex antenna deployment and interference cancellation circuitry for receiving and transmitting simultaneously at the same time at the frequencies. From configuration point of view, they can be treated the same.

The relay system depicted in Figure 1 is more practical in terms of hardware implementation and design, and in addition, the operation suits well to the H-FDD operation already defined in 16e/Rev2. For example, according to the H-FDD frame structure defined in Rev2/D6, both DL and UL frames are split into 2 intervals T1 and T2, one for Group 1 MSs/SSs and one for Group 2 MSs/SSs. During T1 (T2) interval, Group 1 (Group 2) MSs/SSs receive the DL signals from the BS, and during T2 (T1) interval, Group 1 (Group 2) MSs/SSs transmit their UL signals to the BS. This frame structure can be used for a multi-hop relay network with a few modifications, for example, by inserting the optional R-amble, replacing FCH/DL MAP with R-FCH/R-MAP, etc.. In addition, it is also desirable to seek a single-frame approach where more than one relay zone is allowed to appear in a single frame to support FDD MR networks.

Before presenting the amendments for enabling FDD/H-FDD mode in MR networks, we provide some back ground information on the existing H-FDD mode in 16e/Rev2.

FDD and H-FDD mode operation

The parameters related to the frame configuration are signaled in DCD/UCD and DL-MAP. During network entry, an MS first synchronize to an available channel and reads DL-MAP1 to receive DCD/UCD. Initially, MS/SS performs its ranging operation as part of Group 1. There may be one or two DCD/UCD. If there is one DCD/UCD and the same TLV is repeated twice, the first one belongs to user group 1 and the second belongs to user group 2.

MS receives the length of T1 (T2) interval in the current (next) frame from DL-MAP 1 (DL MAP 2), and the UL carrier frequency from UCD. DCD/UCD provides parameters such as DL_gap size, DL_residue gap size and its location, TTGs and RTGs, etc. so that MS/SS can locate exactly the DL and UL intervals within the frame.

MS performs initial ranging assuming itself in group 1. BS can switch the MS user group any time by inserting a H-FDD Group switch IE. If the group switch IE is received at frame n, it becomes effective at frame n+ switch delay + m, where switch delay parameters is specified in UCD, and m is the group number(e.g., for group 1 user, m=1).

In FDD and TDD, DL MAP refers to allocations in the current frame while UL MAP refers to a region in the next frame. In H-FDD, the DL MAP 1 or DL MAP 2 refers to a region in the current frame, while UL MAP 1 refers to next frame, and UL MAP 2 refers to next-next frame.

If full-duplex and half-duplex mobiles exist at the same time, BS can send FDD Paired Allocation IE to schedule those full-duplex mobiles to all H-FDD resources available. The FDD paired allocation IE contains UL MAP IEs that refer to allocations in the other UL region. This IE may also contain UL zone switch IE and UL Allocation start IE, in which case those IEs refer configuration related to the other UL allocation region.

RS and MR-BS Operation in FDD and H-FDD mode

The H-FDD frame structure in 802.16e/Rev2 can be extended to IEEE802.16j with minor modifications.

— Frame configuration: R-link channel description (RCD) MAC message can be employed to signal the access and relay zones. We have the following options:
  - The access zones are contiguous and fall within one of the subframes of H-FDD frame, while the relay zones are contiguous and fall within the other subframe. The FCH/MAP and R-FCH/R-MAP can be transmitted in the first tx access zone and relay zone, respectively. In this case, all the half-duplex MSs/SSs are set as Group 1 users, and all the RSs are set as Group 2 users, (or vice versa) in FDD mode.
  - Each subframe may contain at least one access zone and zero or more relay zones.

— The RS may obtain the UL carrier from the UCD during network entry. For single radio RS, the same carrier frequencies used at the first hop can be used at other hops. For dual-radio RS, the second carrier frequency signaled in RS Config CMD message can refer to DL carrier in FDD mode. In FDD mode, an additional TLV to configure the UL carrier for RS to use in communicating with its subordinate stations can be signaled.

— The RSs can operate in full duplex mode, e.g., may be allocated resources at all H-FDD available resources using HDD Paired Allocation IE. Transparent RSs can monitor both DL MAP 1 and DL MAP 2, and perform relaying according the forwarding rules. In systems where all RSs are transparent, MSs/SSs can be switched between groups.

Proposed Text Changes

[The text recommendations are relative to the IEEE 802.16j/D6 document. The subsection enumeration shall be updated according to the comments from alignment ad-hoc group]

[Change the text in Subclause 8.4.4 as indicated]

8.4.4 Frame structure

In licensed bands, the duplexing method shall be either FDD or TDD. FDD SSs may be full-duplex (FDD) or half-duplex (H-FDD). RSs can also support either FDD or TDD capable SSs. The FDD BS/MR-BS and RS shall support both SS types concurrently. In license-exempt bands, the duplexing method shall be TDD.

8.4.4.7 Frame structure of MR-BS and RS

[Insert new subcluase before 8.4.4.7.1 and re-enumerate all subclauses accordingly]

8.4.4.7.1 TDD mode frame structure

8.4.4.7.1.1 Frame Structure for transparent mode

8.4.4.7.1.1.1 MR-BS frame structure

8.4.4.7.1.1.2 Relay frame structure

8.4.4.7.1.2 Frame structure for non-transparent mode

…

[Insert Subclause 8.4.4.7.2 and the following text]

8.4.4.7.2 FDD mode frame structure

The FDD frame structure described in 8.4.4.1 shall be used at MR-BS, RS and MS with the modifications described in this subclause. Both multi-frame and single-frame frame structures described in 8.4.4.7.2 may be employed.

In MR networks, access zone and transparent or relay zones shall be created within each subframe to enable communication between MR-BS and RS. The establishment, operation and format of these zones are similar to the access zone, transparent and relay zones in TDD operation in Section 8.4.4.7.1. The frame configuration is informed via RCD MAC message (See 11.24.5).

8.4.4.7.2.1 Frame structure for transparent mode

In MR networks, the transparent RSs may be configured to monitor and relay data for both subframe transmissions described in 8.4.4.1. Transparent RSs may be switched between groups in a similar manner to the group switch of MSs.

8.4.4.7.2.1.1 MR-BS frame structure

Each DL subframe (See Figure 225) shall have one access zone and may have one transparent zone for RS to MS transmissions. The MR-BS may also transmit in transparent zone. The transparent zone shall be indicated by an STC_DL_ZONE_IE(), as defined in Table 327. Each UL subframe (See Figure 225) may have an UL access zone and UL relay zone. The UL relay zone shall be indicated by a PAPR Reduction/Safety Zone/Sounding Zone Allocation IE() with Relay Zone indicator set to 1 (see Table 372), or a UL_Zone_IE() (see 8.4.5.4.7).

8.4.4.7.2.1.2 Relay frame structure

The relay frame structure is similar to that of MR-BS. Each DL subframe (See Figure 225) shall have one access zone and may have one transparent zone. Each UL subframe (See Figure 225) shall have one access zone and may have one relay zone. STC DL Zone IE() message may indicate additional power adjustment to be applied to transparent zone in order to reduce the absolute received signal level difference experienced by the MSs served in that zone from MR-BS and from RS paths. This power adjustment is done relative to the EIRP value set for the RS and should not exceed the power levels specified in subclause 8.4.9.6. For monitoring purpose, the relay amble, when present, shall be located at the last OFDM symbol of the DL subframe 1 (See Figure 225).

8.4.4.7.2.2 Frame structure for non-transparent mode

The frame structure defined in 8.4.4.1 is used for MR networks. DL/UL subframe 1 may have at least one access zone and zero or more relay zones. DL/UL subframe 2 may have zero or more access zones and zero or more relay zones. R-FCH and R-MAP shall be transmitted in the first transmit zone of the DL relay zone. MR-BS or RS may allocate resources in both H-FDD groups to full-duplex subordinate stations using the FDD paired allocation IE.

If whole subframe 1 is utilized as access zone and whole subframe 2 is utilized as relay zone, DL subframe 2

comprises of R-FCH, R-MAP and data symbols sent to subordinate RSs (DL subframe 2 is referred to as DL real zone). The MSs/SSs are not required to locate DL Subframe 2 and they shall ignore DL transmissions in this subframe. In this case:

— Group switching of MSs are inhibited in MR networks.
— DCD Alignment for H-FDD is set to 0, and RCD instead of DCD shall be transmitted in DL Subframe 2.
— UCD Alignment for H-FDD is set to 0, and RCD instead of UCD shall be transmitted in DL Subframe 2.
— The RCD configuration count is independent from the DCD or UCD configuration count.

8.4.4.7.2.2.1 MR-BS frame structure

The frame of an MR-BS shall contain at least one access zone in the DL/UL subframe 1. There may be zero or more relay zones within each subframe. The FCH/MAP transmission in DL Subframe 1 shall be defined as in Section 8.4.4.2.The R-FCH/R-MAP transmission shall be defined as in Section 8.4.4.7.3. The relay amble, when present, shall be located at the last OFDM symbol of the first transmit relay zone.

To reduce the overhead, DL (UL) Subframe 1 may be used as DL (UL) access zone to communicate with MSs, and DL (UL) Subframe 2 is used as DL (UL) relay zone to communicate with RSs. RSs and MSs with full-duplex capability may also be scheduled during the UL subframe 1 and 2, respectively. Subframe 1 may have one or more access zones, and Subframe 2 may have one or more relay zones. Any zone may be utilized for transmission, reception or idle. The FCH/MAP transmission in DL Subframe 1 shall be defined as in Section 8.4.4.2.The R-FCH/R-MAP transmission in DL Subframe 2 shall be defined as in Section 8.4.4.7.3. The relay amble, when present, shall be located at the last OFDM symbol of DL subframe.2.

8.4.4.7.2.2.2 Relay frame structure

The relay frame structure is similar to that of MR-BS. A relay may either use the same carrier frequency pair as its super-ordinate station, or may use a different pair of carrier frequencies. The frequency pair that the RS shall use for communicating with its next-hop subordinate stations is informed by RS Config CMD message. Relay subframe 1 contains at least one DL access zone, and zero or more relay zones. Relay subframe 2 contains zero or more access zones and zero or more relay zones. An R-FCH and R-MAP shall be transmitted in the first DL transmit relay zone of DL Subframe.

[Change the table in 11.8.3.7.22 as indicated]

206	1	Bit #0: access zone preamble transmission support Bit #1: MBS Data Synchronization with pre-defined relative transmission time (6.3.23.3) Bit #2: MBS data synchronization with target transmission time (6.3.23.3) Bit #3: cooperative relay support Bit #4: support of a second carrier frequency at RS (see 8.4.4.7.2.2) Bit #5: support dual radio RS operation (see 8.4.4.7.2.3) Bits #6-9: Maximum number of HARQ channels supported in UL_DCH Bit #10: FDD support Bit #11~~0~~-15: Reserved	SBC-REQ SBC-RSP

[Insert the following text at the end of 6.3.2.3.69 - RS Config CMD message]

The RS config CMD message may contain the following TLV:

Second UL carrier configuration (See 11.25.8)

[Change the first row of the table in 11.25.1 as indicated]

1	2	Bit #0: RS scheduling mode, Bit#0=0, centralized scheduling, Bit #0=1, distributed scheduling Bit #1: RS security mode, Bit #1=0, centralized security, Bit #1=1, distributed security Bit #2:0 = shared BSID with other access stations, 1 = unique BSID Bit #3:Embedded path management Bit #4:Explicit path management Bit #5:Reserved Bit #6:Tunnel mode Bit #7:Local CID allocation mode Bit #8: Superordinate RS of an RS group Bit #9: Use a different carrier frequency for subordinate station communication at the RS Bit #10: Operate in dual radio mode Bit #11: Operate in FDD mode Bit #12~~+~~-15: Reserved	RS_Config-CMD

[Insert the following row to the table in 11.25.1 as indicated]

RS second carrier configuration	8	6	Bits #0-23: Centre frequency (kHz) Bits #24-38: Bandwidth (kHz) Bits #39-40: FFT size (0b00: 128FFT; 0b01: 512FFT; 0b10: 1024FFT; 0b11: 2048 FFT) Bits #41-48: reserved	RS_Config-CMD
RS second UL carrier configuration	TBA	4	UL centre frequency (kHz)	RS Config CMD