Project	**IEEE 802.16j Mobile Multihop Relay Task Group**
Title	**Proposal for Multihop Relay Frame Structure for 802.16j**
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Re:	This document is in response to call for technical proposals IEEE 80216-06/027 dated 15 October 2006. This document proposes text regarding frame structure for multihop relay for insertion in baseline document IEEE 80216j-06/026.
Abstract	This contribution proposes a detailed frame structure that efficiently supports multihop relay for IEEE 802.16e. This contribution also provides the technical rationale for the proposed frame structure.
Purpose	Text is included for insertion in the IEEE 802.16j amendment to the standard.
Notice	
Release	
Patent Policy and Procedures	

Proposal for a Frame Structure for IEEE 802.16j

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1 Introduction

This contribution proposes a detailed frame structure for Multihop Relay following the constraints of the Project Authorization Request for Task Group 802.16j. This contribution presents text for insertion into document IEEE 802.16j-06/026 sections 8.4.4.2, 8.4.4.8 and 8.4.6. This document also provides a technical rationale for the proposed multihop relay frame structure.

2 Frame Structure Options

2.1 Time-orthogonal preambles and control

Preambles for IEEE 802.16e are defined in Paragraph 8.4.6.1.1 of IEEE 802.16-2004 as amended by IEEE 802.16e-2005. The preamble is required to be the first OFDMA symbol of every downlink subframe. The OFDMA subcarriers in the preamble are BPSK modulated using the sequences defined in Tables 309a through 309c of IEEE 802.16e-2005 or Table 309 of IEEE 802.16-2004. A total of 114 sequences are defined; these sequences are assigned based upon the Segment and IDcell being used.

A Relay Station must also transmit a preamble at the start of every frame using one of the already-defined PN sequences. It is proposed that Relay Stations be assigned an IDcell just as if they were legacy 802.16e Base Stations and that Relay Stations be associated with a sector and be assigned the same Segment as that sector. The assignment of IDcell to an RS is accomplished as part of the RS network entry procedure and may involve the definition of a new MAC management message.

Asynchronous Base Stations are allowed within the 802.16e standard. In an asynchronous system, handover of an MS from one BS to another is complicated by that fact that MS handover scans must be offset in time. There is no mechanism within the standard to instruct a legacy MS to perform a preamble scan at a known BS-specified offset from the preamble defining the MSs serving BS. Therefore, the handoff process for asynchronous Base Station requires a search for preamble over the full frame duration.

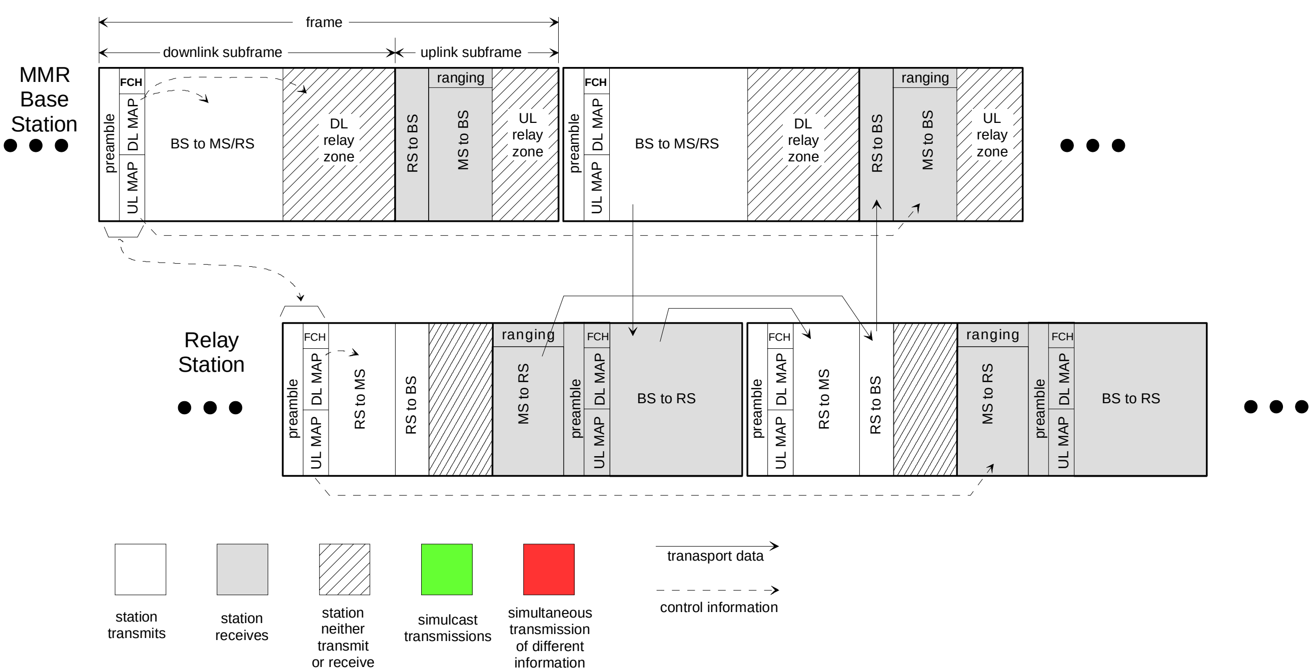

Figure 1. Frame Structure 1 with time offset preambles for RS

One option for positioning of the RS preamble relative to the MMR-BS preamble is illustrated in Figure 1 above. Note that an MS that can receive only RS transmissions receives preambles and a frame structure that looks exactly like the frame structure from the MMR-BS but with a time offset. BS control of the RS frame is achieved via messages sent in two manners. First, the RS receives the normal MMR-BS preamble and the following FCH, DL-MAP and UL-MAP. Second, RS control messages are defined and transmitted from the MMR-BS to the RS embedded within normal transport messaging. These RS control messages include detailed definitions of the time-frequency location of zones reserved for RS preamble and control information transmission, RS transmission to/from its associated MS, and for RS to MMR-BS transmissions. The location and size of these zones in controlled by the MMR-BS in response to changing traffic patterns. Note also that all transmissions by the RS and MMR-BS are compliant with IEEE 802.16e-2005.

It is desirable that the Multihop Relay system concept be flexible enough to permit either centralized control of all transmissions within the MMR cell or some amount of distributed control. It is anticipated that some designs would allocate blocks of time-frequency resources to the RS and delegate authority to the RS to assign these resources to specific MS communications. The frame structure of Figure 1 permits decentralized control since it is not required that the MAPs transmitted by the MMR-BS be identical to the MAPs transmitted by the RS.

This frame structure is the most straightforward of the structures discussed herein. All MMR-BS and RS transmissions are orthogonal in time and/or frequency. All transmission are fully compliant with IEEE 802.16e-2005. The illustration in Figure 1 show detailed frame partitioning for a single RS associated with a single MAC instance at the MMR-BS. More than one RS may be associated with a single instance of the MAC by further partitioning the time-frequency resource allocated to the RS.

Disadvantages of this frame structure are: 1) handover between an MMR-BS and an RS is complicated by the preamble time offset; 2) spectrum resources are not used efficiently by requiring time orthogonal transmission of the MMR-BS and RS preambles and frame control information.

2.2 Synchronized preambles at the RS and MMR-BS

Synchronizing the start of the frame at the MMR-BS with the start of the frame at the RS facilitates handover processes since the size of the search window for handover measurement is minimized. Figure 2 illustrates a frame structure having synchronized preamble transmissions. Note, however, that even though the preambles are time synchronous, the preamble PN sequence used by the MMR-BS and the RS use different codes from Table 309 through 309d of Section 8.4.6.1.1 of IEEE Std 802.16e-2005. These codes have sufficiently low cross-correlation that the MS receiver can distinguish these transmissions. The assignment of preamble sequences via the assignment of IDcell and Segment to an RS will be accomplished as part of the network entry procedure. For mobile relay stations the preamble may be reassigned as part of the handover process. New MAC management messaging may be required for this assignment. Further, different FCH, DL-MAPs, and UL-MAPs are transmitted from the MMR-BS and the RS. This frame structure mitigates both of the disadvantages identified for the frame of Figure 1.

This frame structure defines time-frequency-orthogonal zones reserved exclusively for MMR-BS to RS transmissions and for RS to MMR-BS transmissions. The location of these zones is specified to the RS in the RS control information immediately following the RS preamble. The location of these zones is also specified in both the DL-MAP and in the RS-DL-MAP. The frame is designed such that there are no transmissions to or from any MS in these zones so that it is possible to enhance the physical layer in these zones to enable higher spectrum efficiency. It is expected that these links are advantaged relative to link to/from an MS because directional antennas may be used at the RS to achieve higher CINR and also because line-of-sight propagation may be achieved resulting in potentially better multipath (possibly line-of-sight) characteristics. Simulation studies have demonstrated that high spectrum efficiency on the RS-to-MMR-BS links will be important to the overall system gains for the Multihop Relay system that is the goal of this amendment. Note that the reserving of time-frequency orthogonal zones for RS to/from MMR-BS communications does not require that the physical layer be enhanced. Rather, this zone makes possible an enhanced RS to/from MMR-BS in the future.

RS network entry can utilize either the MMR-BS preamble or the RS preamble. If the RS detects the 802.16j defined RS preambles transmitted immediately following the UL-MAP, synchronization is immediate and the RS is informed of the frame structure in the RS control information immediately following. If, however, the RS detects the normal preamble, it then decodes the following FCH, DL-MAP, and UL-MAP where it finds a pointer to the RS-preamble. In this second case, the RS resynchronizes immediately using the RS preamble. The new preambles must all have minimum cross-correlation between the sequences defined in IEEE Std

802.16 Table 309 through 309d. Following synchronization and network entry, the RS transmits standard 802.16e preamble plus RS-DL-MAP and RS-UL-MAP to MS attached to that RS.

Information transmitted within the BS to/from RS relay zones includes both control messaging as well as user data transport. Information transmitted within the RS to BS relay zone must also support control messaging and user data transport. Control messaging may include MS bandwidth requests, MS ranging reports, MS channel measurements, the RS-MAPs, and others. Transmitting the RS-MAPs on this link is needed when distributed system control is used. New MAC messages will be defined. These new messages may be mandatory for a centrally controlled system and optional when distributed control is permitted.

The MMR-BS manages all time-frequency allocations within the frame. For its own transmissions and the transmissions of MS directly connected to the MMR-BS, all control is fully compliant with IEEE 802.16e-2005. For control of transmissions by associated RSs, new MAC messages are defined to inform the RS of the precise time-frequency resources it must use for transmissions to/from the MMR-BS and to/from the MS associated with that RS. The RS-transmitted preamble and following MAPs (transmitted simultaneously with the MMR-BS preamble and MAPs) are fully compliant with IEEE 802.16e-2005. However, the RS-transmitted MAPs define the DL and UL regions for MSs attached to the RS and are therefore different from the MAPs transmitted by the MMR-BS. The RS-transmitted MAPs may be created at the MMR-BS and communicated to the RS via new control messages used on the MMR-BS to RS link or may be generated at the RS using constraints and information communicated by the MMR-BS. The size of these new control messages may be compressed to enhance overall system spectrum efficiency. Decentralized resource management is also possible with the frame structure of Figure 2 because a different UL and DL MAPs are transmitted from the MMR-BS and from the RS. Time varying need for relaying is accommodated in this frame structure since all MS (relayed or not) are frame synchronous so that the allocations for relay zones may vary from frame to frame via time varying of the MAP information. This potential varying of the relay zones may also vary the position of the uplink ranging allocation; the location of the ranging allocation is known to the MS via the MAP information. The location of the RS preamble will be fixed and will not vary from frame to frame even if traffic patterns do change.

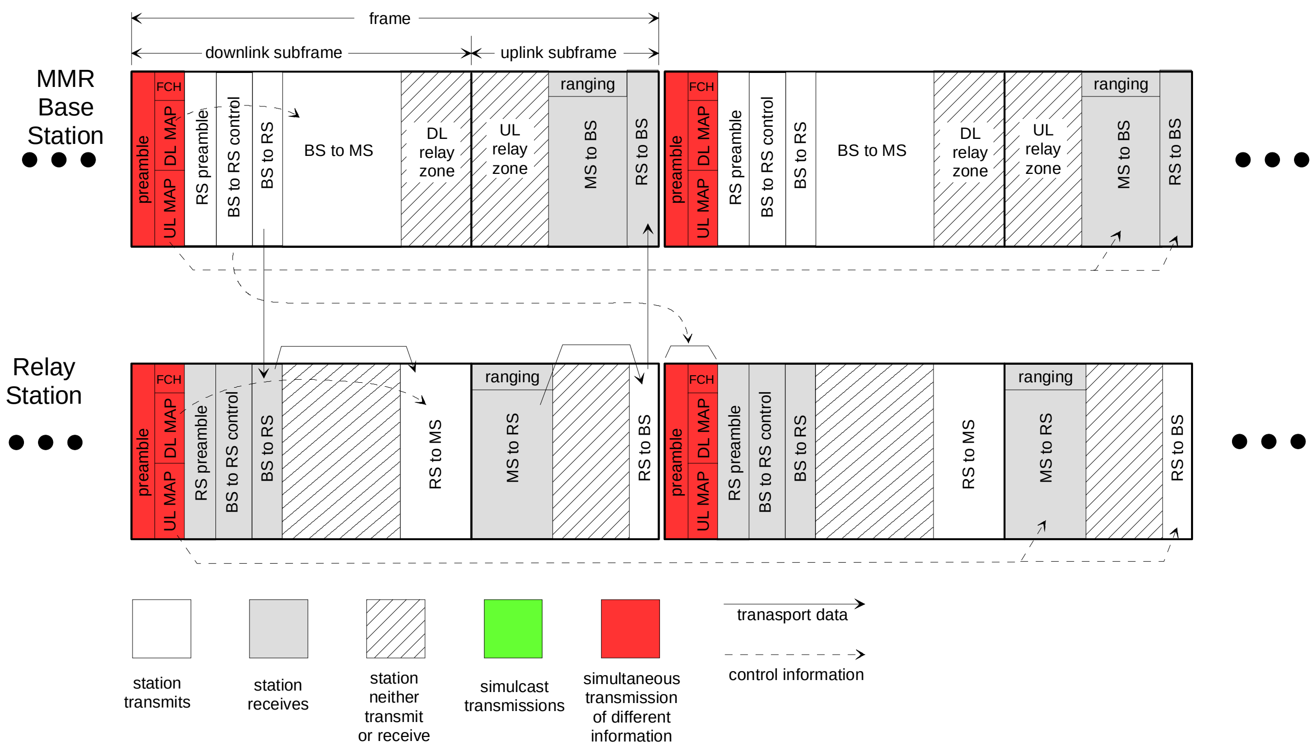

Figure 2. Frame structure 2a with synchronized preambles

The time relevance of both the UL-MAP and the proposed RS-UL-MAP will be unchanged from the time relevance defined in IEEE 802.16e-2005. Specifically, both MAPs may define uplink transmissions within the current frame or within the immediately following frame. The minimum and maximum relevance is illustrated in IEEE 802.16-2004 Figure 46 and Figure 47.

Because the RS and the MMR-BS are transmitting preambles and MAPs simultaneously, it is not possible for the RS to receive control information at during these transmissions. Thus, a disadvantage of this scheme is that a separate transmission by the MMR-BS of RS control information is required. As illustrated in Figure 2, this RS control information is transmitted by the MMR-BS following the usual MAPs and preamble after allowing a short guard time (not illustrated in the figure) for the RS to switch from transmit to receive mode.

CINR for the periods where both the RS and MMR-BS are transmitting simultaneously is a consideration for this scheme. Transmit power and modulation and coding strategy will be managed so that both transmissions may be reliably received at their target transceivers. Preliminary simulations have indicated that CINR statistics for the case where RSs are transmitting simultaneously with the MMR-BSs is not appreciably degraded relative to the non-relayed system.

The frame structure illustrated in Figure 2 does not show all required time gaps for transceivers to switch from transmit mode to receive mode. These transition times are typically significantly less than one OFDMA symbol and may be safely ignored in some discussions. However, the transmit/receive gap for the relay station in Figure 2 must be one complete OFDMA symbol. The reason for this is the fact that symbol timing must be maintained in the downlink subframe for MS that are receiving after the RS-preamble other BS-to-RS transmissions. In order to mitigate the capacity loss that would result from this large transmit/receive time gap, two alternative frame structures are illustrated in Figure 3 and in Figure 4 below.

The alternative structure of Figure 3 solves this problem by moving the RS-preamble and following BS-to-RS transmissions two OFDMA symbols or more later in the frame. The two symbols immediately following the normal preamble, FCH, and MAPs are now used for BS-to-MS data transmission. During these two symbols, the relay station has sufficient time to transition from transmit to receive. It is also acceptable to move these transmission later in the frame, however, moves must be in increments of two symbol times in order to enable downlink slots to fill the space vacated by the MMR-BS to RS signaling. Additionally, if these tranmissions are moved to near the end of the DL dubframe, they must end at least two symbols prior to the end of this period or must be moved completely to the end of the downlink subframe as in the strategy below.

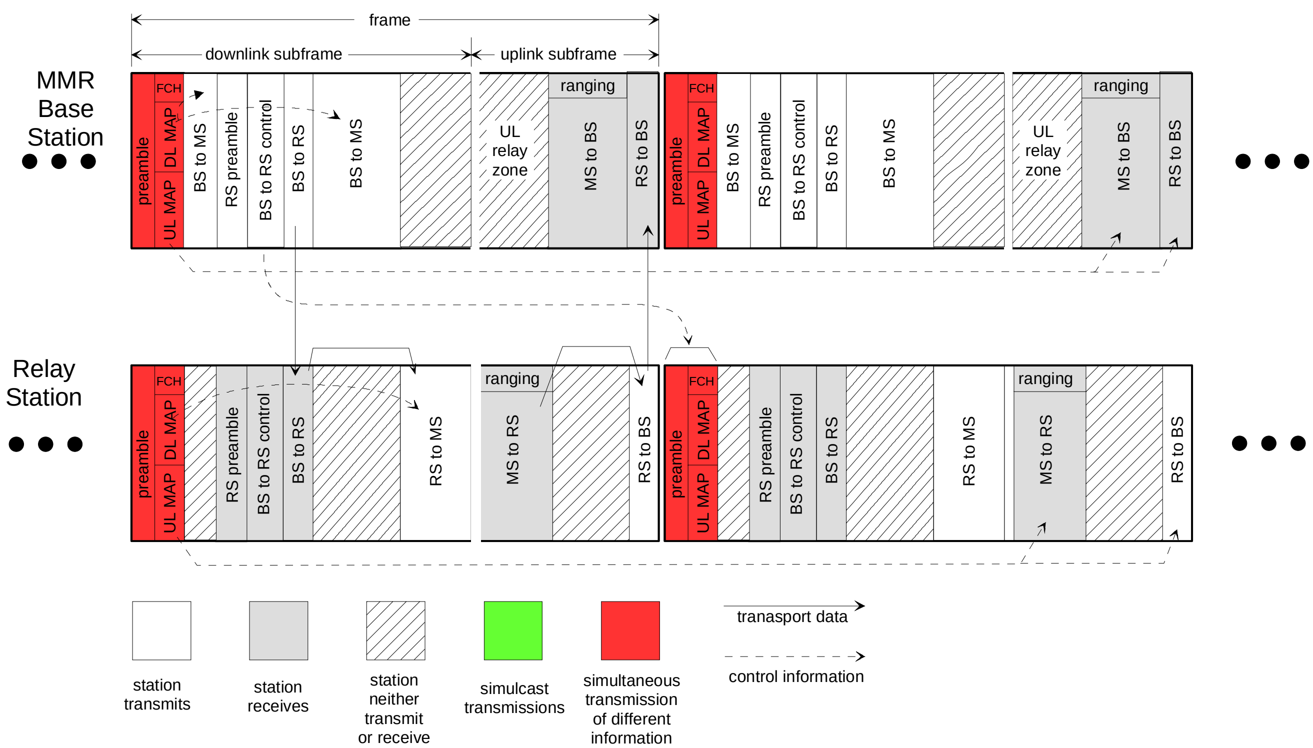

Figure 3. Alternative Frame Structure 2b

The alternative of Figure 4 solves the problem by moving the BS-to-RS transmission to the end of downlink subframe. This, of course, requires that the user data transmitted from the BS to the RS as part of these transmission be user data that will be sent to the BS in the following frame as illustrated. This frame structure is slightly less spectrum efficient than the frame structure of Figure 3 because a transmit/receive time gap must be included for the relay station following its transmissions to mobile stations.

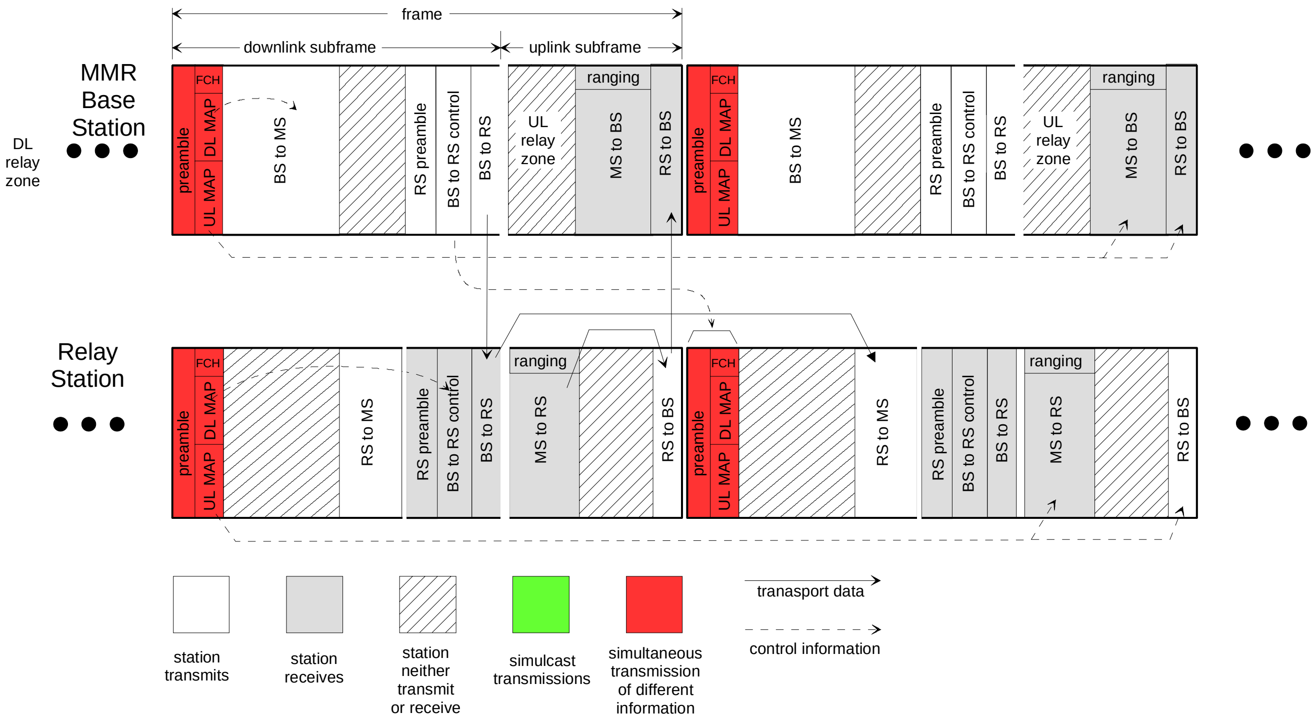

Figure 4. Alternative Frame Structure 2c

These frame structures support all goals of the 802.16j Task Group including range extension, capacity increase and coverage hole mitigation. For range extension and coverage hole mitigation it is possible to relay both control information as well as user data to/from an MS. For capacity increase it is possible to relay only user data and communicate control information directly to/from the MMR-BS. It is also possible to relay only the uplink user data as further described in contribution C80216j-06/160 on the topic of transparent relaying.

2.3 Simulcast for preamble and control information

Figure 5 below illustrates a third frame structure that differs from that of Figure 2 in that preamble and control information is *simulcast* by the MMR-BS and the RS at the start of each frame. This frame structure was considered to determine whether or not simulcast would provide significant system gains. All discussion within Section 2.2 is applicable to this frame structure with the following exceptions:

1) Since simulcast is used, the preamble and control information transmitted by the RS is identical to the information transmitted by the MMR-BS. Thus, this structure is applicable only to a centrally controlled system.

2) Preamble measurements by the MS reflect the combined signals from both the MMR-BS and the RS. This will complicate handover as well as MS initialization functions.

It is possible that simulcast could be useful for both range extension as well as coverage hole mitigation. Further study would be required to assess whether the potential benefits are superior to similar benefits for the frame structure of Figure 2 and would thus motivate solutions to the problem identified in item 2 above. Finally, this structure requires that all of the MMR-BS DL-MAP and UP-MAP details be communicated to the RS. These transmissions, of course, require time-frequency resources that might otherwise be used for transport data.

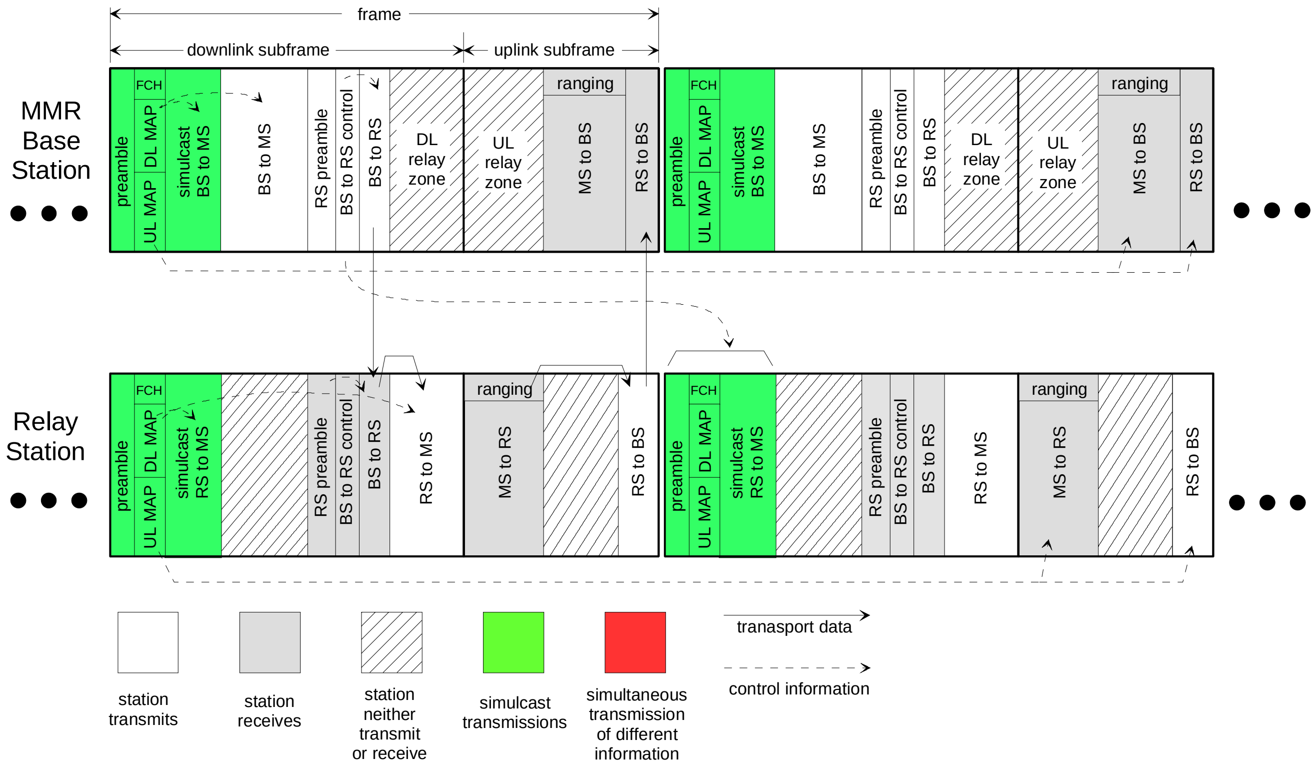

Figure 5. Frame Structure 3 using simulcast transmission

2.4 No preamble transmitted by RS

Figure 6 illustrates a frame structure that eliminates the transmission of the preamble, FCH, and MAPs by the RS. It is therefore required that the MS be controlled by the MMR-BS using standard IEEE 802.16e-2005 control mechanisms. This frame structure does not support range extension.

The primary advantage of this frame structure is that it may support less complex RS than any of the other structures. The RS is used only for user transport data on both the downlink and the uplink. On the downlink simulcast of user data is optionally employed to further support coverage extension and throughput increase for disadvantaged MS. Note that some user data is simulcast while other user data is not or is possibly simulcast by a different RS. This frame structure may be efficient for support of transparent relaying as discussed in contribution C80216j-06/TBD.

An important difficulty with this frame structure is that attachment of MS. Since there is no RS preamble, the MS cannot take measurements in support of routing decisions. This problem is mitigated by using RS measurements of the MS initial and periodic ranging signals and reporting these results to the MMR-BS.

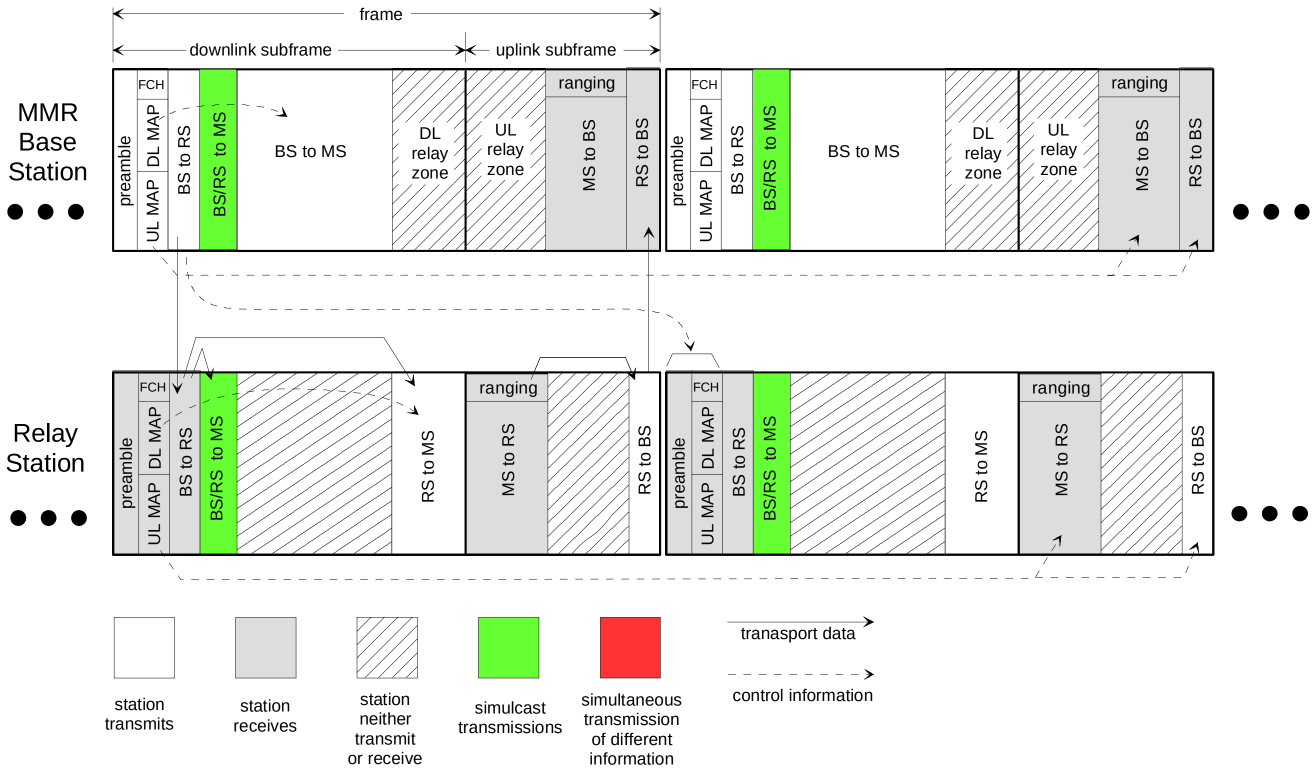

Figure 6. Frame Structure 4 without RS preamble

2.5 Recommended frame structure

The frame structure of Figure 2 is recommended for IEEE 802.16j. This recommendation supports all of the goals of the Relay Task Group including range extension, throughput enhancement, capacity increase, and coverage improvement. The key attributes of this frame structure are:

- The use of a dedicated zone for communications between the RS and the MMR-BS. Legacy 802.16e MS are not allowed to transmit in this zone and are not expected to receive in this zone. Thus, both the medium access and physical layers within this zone may be enhanced to achieve higher spectrum efficiency. Increased spectrum efficiency on this link will be important to the overall system-level effectiveness of Multihop Relay.
- Frame synchronization between the MMR-BS and all RS. While asynchronous system are permitted within for 802.16, synchronous systems appear to have more industry support and are therefore preferable for 802.16j. This frame synchronization greatly facilitates the handover procedures for 802.16j.

The frame structure of Figure 2 specifically supports a system using a single relay (two hops) in any one path. This frame structure is extended to support multiple hops as illustrated in Figure 7. In this figure, additional zones are allocated for RS1 to RS2 communications. The extension to even more hops is obvious.

The specific proposals for text in Section 3 defines many aspects of the proposed frame structure. Additional contributions that define specific messaging mentioned in the paragraphs above are expected.

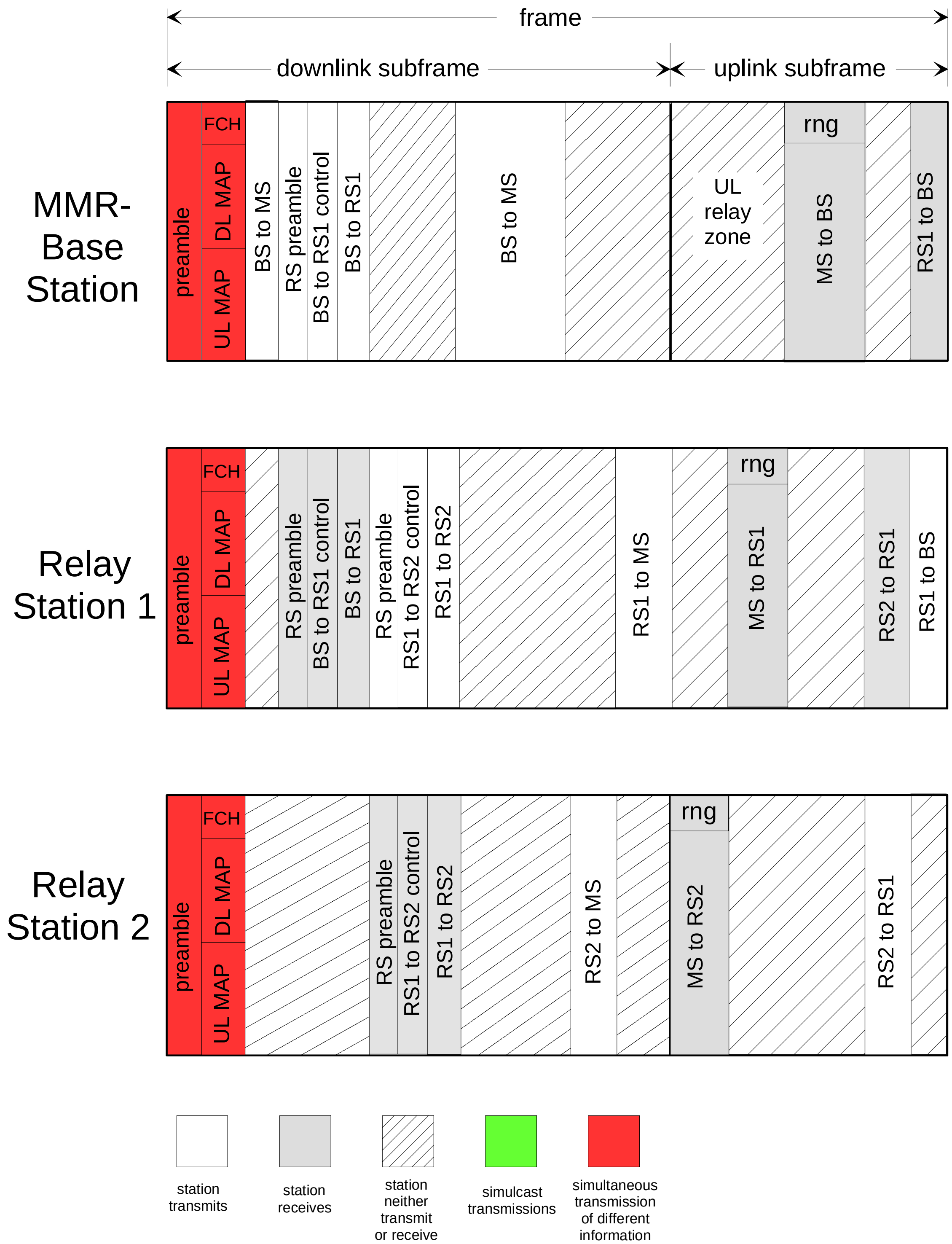

Figure 7. Extension of recommended frame structure to support multiple hops.

3 Proposed text for Insertion into Section 8.4.4.8 of IEEE 802.16j-06/026

Three options for frame structure are presented below. We recommend option 2 for IEEE 802.16j but present three options for discussion within the Task Group.

Option 1: Insert the following as "Section 8.4.4.8 Relaying Frame Structure"

Multihop relay is supported for TDD systems by extending the frame structure of Section 8.4.4.2 to include orthogonal time-frequency zones for MMR-BS to/from MS communications, for MMR-BS to/from RS communications, and for RS to/from MS communications. Figure 8 depicts the Relaying Frame Structure from the perspective of the MMR-BS and Figure 9 depicts the Relaying Frame Structure from the perspective of the RS. The MMR-BS frame and the RS frame are time-frequency synchronous. RS transmit timing is advanced so that all signals at the MMR-BS arrive precisely within their allocations with reference to the MMR-BS. MS served by an RS are time advanced so that their signals arrive at the RS precisely within their allocations with reference to the RS. An MS cannot be simultaneously time synchronous with both the RS and the MMR-BS; interference caused by this timing offset is mitigated by the scheduler. Each frame is partitioned into a downlink subframe and an uplink subframe. Each frame is further partitioned to include relay zones. A TTG or RTG shall be inserted at each time instance where either the RS or the MMR-BS is required to change from transmit to receive or vice versa. A TTG or RTG is uncecessary for instances where the frame structure itself has multiple OFDMA symbols between transmit and receive assignments. At both the MMR-BS and the RS, each frame begins with a preamble followed immediately by FCH, DL-MAP, UL-MAP, RS-preamble, and a zone for MMR-to-RS control information. The DL and UL MAPs transmitted simultaneously by the MMR-BS and the RS each contain their own (possibly different) information.

The multihop relay frames depicted in Figure 8 and Figure 9 apply to a system using two hops and a single relay supported by a single instance of the MAC. This frame is extended to support multiple relay stations each participating in two-hop communications by partitioning the relay zones in the frequency domain. This frame is extended to support multiple hop by including additional relay zones for each additional hop.

The scheduler for relaying must make allowances for the time required for an MS or an RS to switch from transmit to receive. Specifically, the MMR-BS or an RS shall not transmit downlink information to an MS station later than (MSRTG+RTD) or to an RS later than (RSRTG+RTD) before the beginning of its first scheduled uplink allocation in any UL subframe. Also, the MMR-BS or an RS shall not transmit downlink information to an MS earlier than (MSTTG-RTD) or to an RS earlier than (RSTTG-RTD) after the end of the last scheduled uplink allocation, where RTD denotes Round Trip Delay. In addition the MS should be allowed to receive the downlink preamble for each frame that contains DL data for it by assuring the period specified above does not overlap with the preamble. The parameters MSRTG, MSTTG, RSRTG, and RSTTG are capabilities provided by the MS or the RS to the MMR-BS during network entry.

Subchannel allocation in the downlink may be performed in the following ways: partial usage of subchannels (PUSC) where some of the subchannels are allocated to the transmitter, and full usage of the subchannels (FUSC) where all subchannels are allocated to the transmitter. The FCH shall be transmitted using QPSK rate 1/2 with four repetitions using the mandatory coding scheme (i.e., the FCH information will be sent on four subchannels with successive logical subchannel numbers) in a PUSC zone. The FCH contains the DL_Frame Prefix as described in 8.4.4.3 and specifies the length of the DL-MAP message that immediately follows the DL_Frame Prefix and the repetition coding used for the DL-MAP message.

The transitions between modulations and coding take place on slot boundaries in the time domain (except in AAS zone) and on subchannels with an OFDMA symbol in the frequency domain.

The OFDMA multihop relay frame will include multiple zones. In addition to PUSC, FUSC, PUSC with all subchannels, optional FUSC, AMC, TUSC1, and TUSC2, the following zones are defined: a) RS downlink zone 1, b) RS downlink zone 2, c) RS uplink zone 1, and d) RS uplink zone 2. The RS preamble, RS control information, and first hop downlink MS transport data is transmitted by the MMR-BS to the RS in RS Downlink Zone 1. The second downlink hop MS transport data is transmitted by the RS to another RS or to an MS in RS Downlink Zone 2. The first hop MS transport data as well as control information is received by the RS in RS Uplink Zone 1. The RS control information as well as the second hop uplink MS transport data is transmitted by the RS to the MMR-BS in RS Uplink Zone 2.

The transition between zones is indicated in the DL-MAP by the STC_DL_Zone IE (see 8.4.5.3.4) or AAS_DL_IE (see 8.4.5.3.3.). No DL-MAP or UL-MAP allocations can span over multiple zones. Figure 219 depicts the OFDMA frame with multiple zones.

The following restrictions apply to downlink allocations:

a) The maximum number of non-relay downlink zones is 6 in one downlink subframe.

b) For each MS, the maximum number of bursts to decode in one downlink subframe is 64. This includes all bursts without CID or with CID matching the MS's CIDs.

c) For each MS, the maximum number of bursts transmitted concurrently and directed to the MS is limited by the value specified in Max_Num_Bursts TLV (including all bursts without CID or with CID matching the MS's CIDs) . Bursts transmitted concurrently are bursts that share the same OFDMA symbol. Before MS completed capability exchange BS shall transmit data to the MS in the first concurrent data burst per symbol.

d) At least two relay zones shall be allocated in every downlink subframe. The relay zone allocation may be null.

e) At least two relay zones shall be allocated in every uplink subframe. The relay zone allocation may be null.

If the MMR-BS allocates more bursts or zones, then the MS is required to decode the first bursts/zones until the limit is reached.

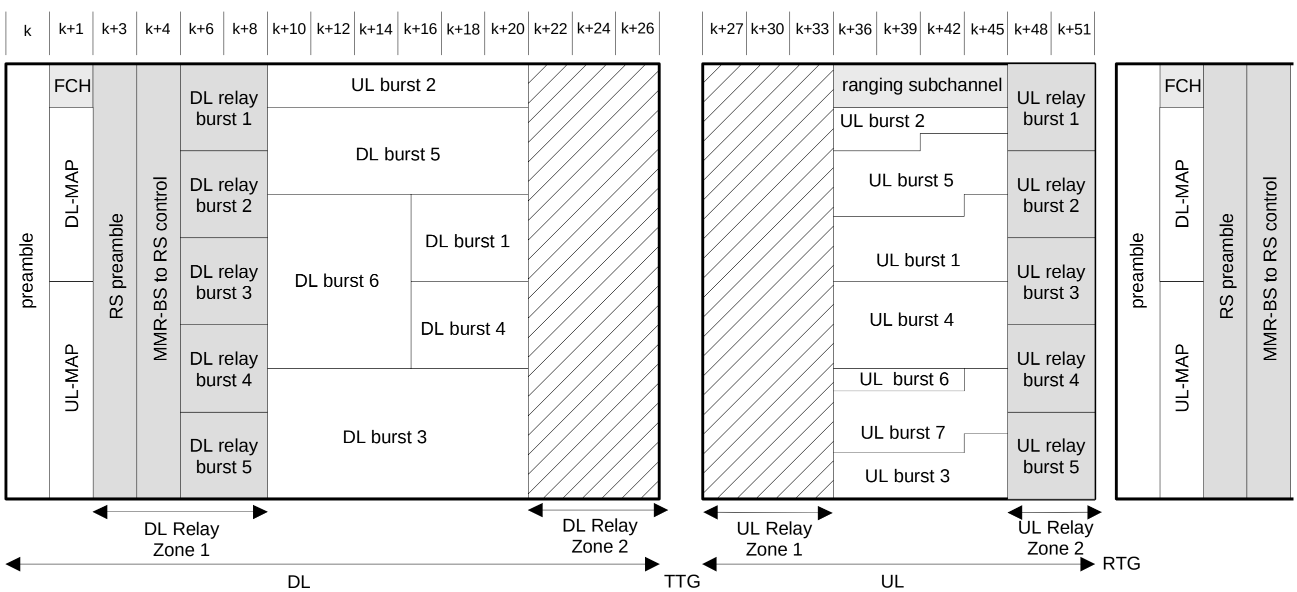

Figure 8. Frame Structure 2a from point of view of the MMR-BS (option 1)

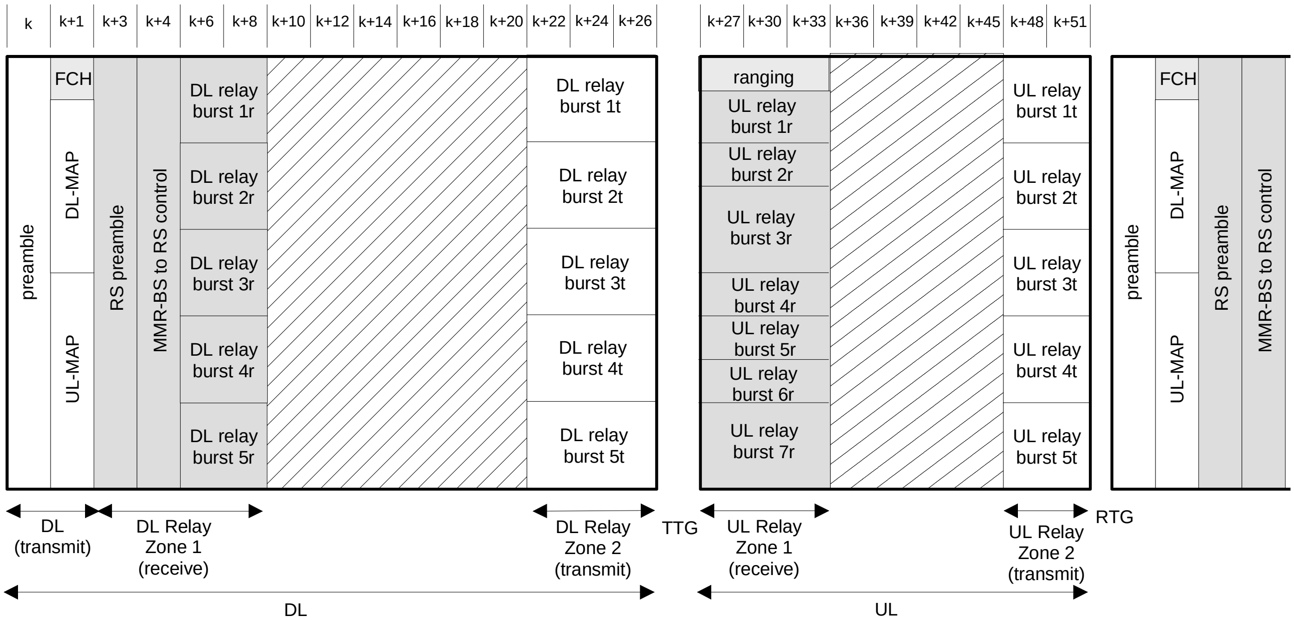

Figure 9. Frame Structure 2a from point of view of the RS. (option 1)

Option 2: Insert the following as "Section 8.4.4.8 Relaying Frame Structure"

Multihop relay is supported for TDD systems by extending the frame structure of Section 8.4.4.2 to include orthogonal time-frequency zones for MMR-BS to/from MS communications, for MMR-BS to/from RS communications, and for RS to/from MS communications. Figure 10 depicts the Relaying Frame Structure from the perspective of the MMR-BS and Figure 11 depicts the Relaying Frame Structure from the perspective of the RS. The MMR-BS frame and the RS frame are time-frequency synchronous. RS transmit timing is advanced so that all signals at the MMR-BS arrive precisely within their allocations with reference to the MMR-BS. MS served by an RS are time advanced so that their signals arrive at the RS precisely within their allocations with reference to the RS. An MS cannot be simultaneously time synchronous with both the RS and the MMR-BS; interference caused by this timing offset is mitigated by the scheduler. Each frame is partitioned into a downlink subframe and an uplink subframe. Each subframe is further partitioned to include relay zones. A TTG or RTG shall be inserted at each time instance where either the RS or the MMR-BS is required to change from transmit to receive or vice versa. A TTG or RTG is uncecessary for instances where the frame structure itself has multiple OFDMA symbols between transmit and receive assignments. At both the MMR-BS and the RS, each frame begins with a preamble followed immediately by FCH, DL-MAP, UL-MAP, and then at least two OFDMA symbols used for MMR-BS to MS bearer data. This bearer data zone may be larger than two OFDMA symbols but must be an integer multiple of two OFDMA symbols in length. The bearer data zone is followed by a one symbol RS-preamble, a zone for MMR-to-RS control information and a zone for MMR-to-RS bearer data. The zones for MMR-to-RS control and bearer data information shall be an odd number of OFDMA symbols in length so that correct slot synchronization for MMR-BS connected MS is achieved after DL Relay Zone 1. The DL and UL MAPs transmitted by the MMR-BS and the RS each contain their own (possibly different) information.

The multihop relay frames depicted in Figure 10 and Figure 11 apply to a system using two hops and a single relay supported by a single instance of the MAC. This frame is extended to support multiple relay stations each participating in two-hop communications by partitioning the relay zones in the frequency domain. This frame is extended to support multiple hop by including additional relay zones for each additional hop.

The scheduler for relaying must make allowances for the time required for an MS or an RS to switch from transmit to receive. Specifically, the MMR-BS or an RS shall not transmit downlink information to an MS station later than (MSRTG+RTD) or to an RS later than (RSRTG+RTD) before the beginning of its first scheduled uplink allocation in any UL subframe. Also, the MMR-BS or an RS shall not transmit downlink information to an MS earlier than (MSTTG-RTD) or to an RS earlier than (RSTTG-RTD) after the end of the last scheduled uplink allocation, where RTD denotes Round Trip Delay. In addition the MS should be allowed to receive the downlink preamble for each frame that contains DL data for it by assuring the period specified above does not overlap with the preamble. The parameters MSRTG, MSTTG, RSRTG, and RSTTG are capabilities provided by the MS or the RS to the MMR-BS during network entry.

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a) The maximum number of non-relay downlink zones is 6 in one downlink subframe.

b) For each MS, the maximum number of bursts to decode in one downlink subframe is 64. This includes all bursts without CID or with CID matching the MS's CIDs.

c) For each MS, the maximum number of bursts transmitted concurrently and directed to the MS is limited by the value specified in Max_Num_Bursts TLV (including all bursts without CID or with CID matching the MS's CIDs) . Bursts transmitted concurrently are bursts that share the same OFDMA symbol. Before MS completed capability exchange BS shall transmit data to the MS in the first concurrent data burst per symbol.

d) At least two relay zones shall be allocated in every downlink subframe. The relay zone allocation may be null.

e) At least two relay zones shall be allocated in every uplink subframe. The relay zone allocation may be null.

If the MMR-BS allocates more bursts or zones, then the MS is required to decode the first bursts/zones until the limit is reached.

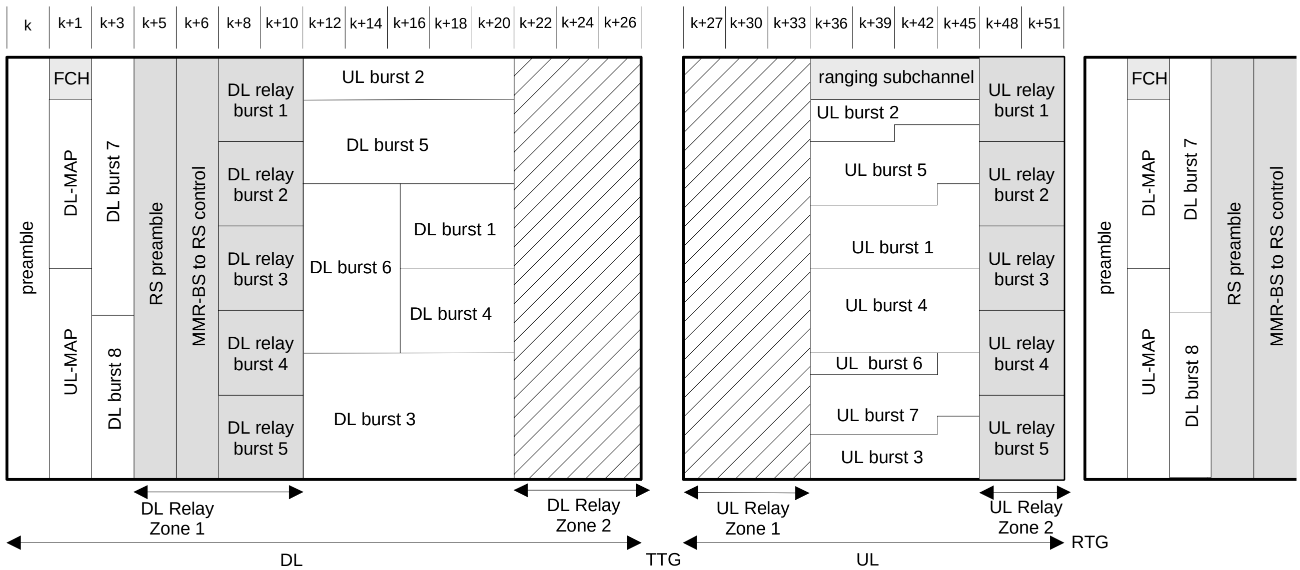

Figure 10. Frame Structure 2b from point of view of the MMR-BS (option 2)

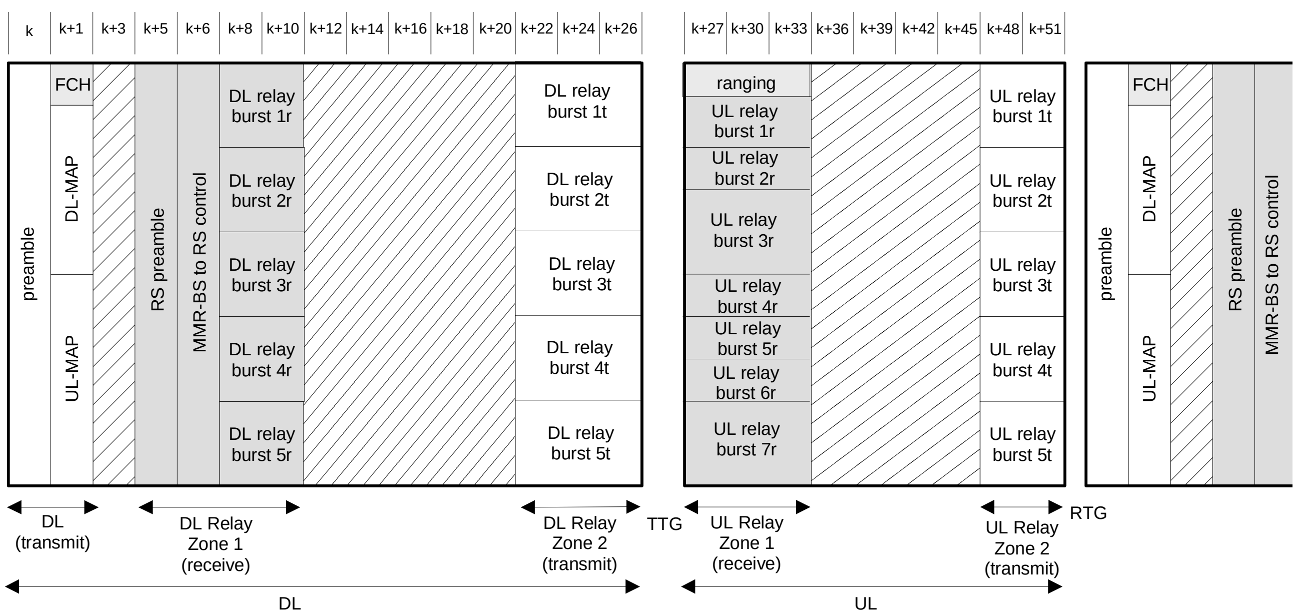

Figure 11. Frame Structure 2b from point of view of the RS (option 2).

Option 3: Insert the following as "Section 8.4.4.8 Relaying Frame Structure"

Multihop relay is supported for TDD systems by extending the frame structure of Section 8.4.4.2 to include orthogonal time-frequency zones for MMR-BS to/from MS communications, for MMR-BS to/from RS communications, and for RS to/from MS communications. Figure 12 depicts the Relaying Frame Structure from the perspective of the MMR-BS and Figure 13 depicts the Relaying Frame Structure from the perspective of the RS. The MMR-BS frame and the RS frame are time-frequency synchronous. RS transmit timing is advanced so that all signals at the MMR-BS arrive precisely within their allocations with reference to the MMR-BS. MS served by an RS are time advanced so that their signals arrive at the RS precisely within their allocations with reference to the RS. An MS cannot be simultaneously time synchronous with both the RS and the MMR-BS; interference caused by this timing offset is mitigated by the scheduler. Each frame is partitioned into a downlink subframe and an uplink subframe. Each subframe is further partitioned to include relay zones. A TTG or RTG shall be inserted at each time instance where either the RS or the MMR-BS is required to change from transmit to receive or vice versa. A TTG or RTG is uncecessary for instances where the frame structure itself has multiple OFDMA symbols between transmit and receive assignments. At both the MMR-BS and the RS, each frame begins with a preamble followed immediately by FCH, DL-MAP, UL-MAP and then followed by user bearer data from the MMR-BS to the MS. Relay Zone 2 follows the MMR-to-BS bearer data zone. During Relay Zone 2, the RS transmits bearer data to MS. A TTG gap follows Relay Zone 2. The TTG is followed by Relay Zone 1 where the MMR-BS transmits RS-preamble, MMR-to-RS control information, and bearer data to the RS. The DL and UL MAPs transmitted by the MMR-BS and the RS each contain their own (possibly different) information.

The multihop relay frames depicted in Figure 12 and Figure 13 apply to a system using two hops and a single relay supported by a single instance of the MAC. This frame is extended to support multiple relay stations each participating in two-hop communications by partitioning the relay zones in the frequency domain. This frame is extended to support multiple hop by including additional relay zones for each additional hop.

The scheduler for relaying must make allowances for the time required for an MS or an RS to switch from transmit to receive. Specifically, the MMR-BS or an RS shall not transmit downlink information to an MS station later than (MSRTG+RTD) or to an RS later than (RSRTG+RTD) before the beginning of its first scheduled uplink allocation in any UL subframe. Also, the MMR-BS or an RS shall not transmit downlink information to an MS earlier than (MSTTG-RTD) or to an RS earlier than (RSTTG-RTD) after the end of the last scheduled uplink allocation, where RTD denotes Round Trip Delay. In addition the MS should be allowed to receive the downlink preamble for each frame that contains DL data for it by assuring the period specified above does not overlap with the preamble. The parameters MSRTG, MSTTG, RSRTG, and RSTTG are capabilities provided by the MS or the RS to the MMR-BS during network entry.

Subchannel allocation in the downlink may be performed in the following ways: partial usage of subchannels (PUSC) where some of the subchannels are allocated to the transmitter, and full usage of the subchannels (FUSC) where all subchannels are allocated to the transmitter. The FCH shall be transmitted using QPSK rate 1/2 with four repetitions using the mandatory coding scheme (i.e., the FCH information will be sent on four subchannel with successive logical subchannel numbers) in a PUSC zone. The FCH contains the DL_Frame Prefix as described in 8.4.4.3 and specifies the length of the DL-MAP message that immediately follows the DL_Frame Prefix and the repetition coding used for the DL-MAP message.

The transitions between modulations and coding take place on slot boundaries in the time domain (except in AAS zone) and on subchannels with an OFDMA symbol in the frequency domain.

The OFDMA multihop relay frame will include multiple zones. In addition to PUSC, FUSC, PUSC with all subchannels, optional FUSC, AMC, TUSC1, and TUSC2, the following zones are defined: a) RS Downlink Zone 1, b) RS Downlink Zone 2, c) RS Uplink Zone 1, and d) RS Uplink Zone 2. The RS preamble, RS control information, and first hop downlink MS bearer data is transmitted by the MMR-BS in RS Downlink Zone 1. The bearer data transmitted to the RS during Downlink Zone 1 is relayed to the MS during Downlink Zone 2 of the immediately following frame. The first hop MS transport data as well as control information is received by the RS in RS Uplink Zone 1. The RS control information as well as the second uplink MS transport data is transmitted by the RS to the MMR-BS in RS Uplink Zone 2.

The transition between zones is indicated in the DL-MAP by the STC_DL_Zone IE (see 8.4.5.3.4) or AAS_DL_IE (see 8.4.5.3.3.). No DL-MAP or UL-MAP allocations can span over multiple zones. Figure 219 depicts the OFDMA frame with multiple zones.

The following restrictions apply to downlink allocations:

a) The maximum number of non-relay downlink zones is 6 in one downlink subframe.

b) For each MS, the maximum number of bursts to decode in one downlink subframe is 64. This includes all bursts without CID or with CID matching the MS's CIDs.

c) For each MS, the maximum number of bursts transmitted concurrently and directed to the MS is limited by the value specified in Max_Num_Bursts TLV (including all bursts without CID or with CID matching the MS's CIDs) . Bursts transmitted concurrently are bursts that share the same OFDMA symbol. Before MS completed capability exchange BS shall transmit data to the MS in the first concurrent data burst per symbol.

d) At least two relay zones shall be allocated in every downlink subframe. The relay zone allocation may be null.

e) At least two relay zones shall be allocated in every uplink subframe. The relay zone allocation may be null.

If the MMR-BS allocates more bursts or zones, then the MS is required to decode the first bursts/zones until the limit is reached.

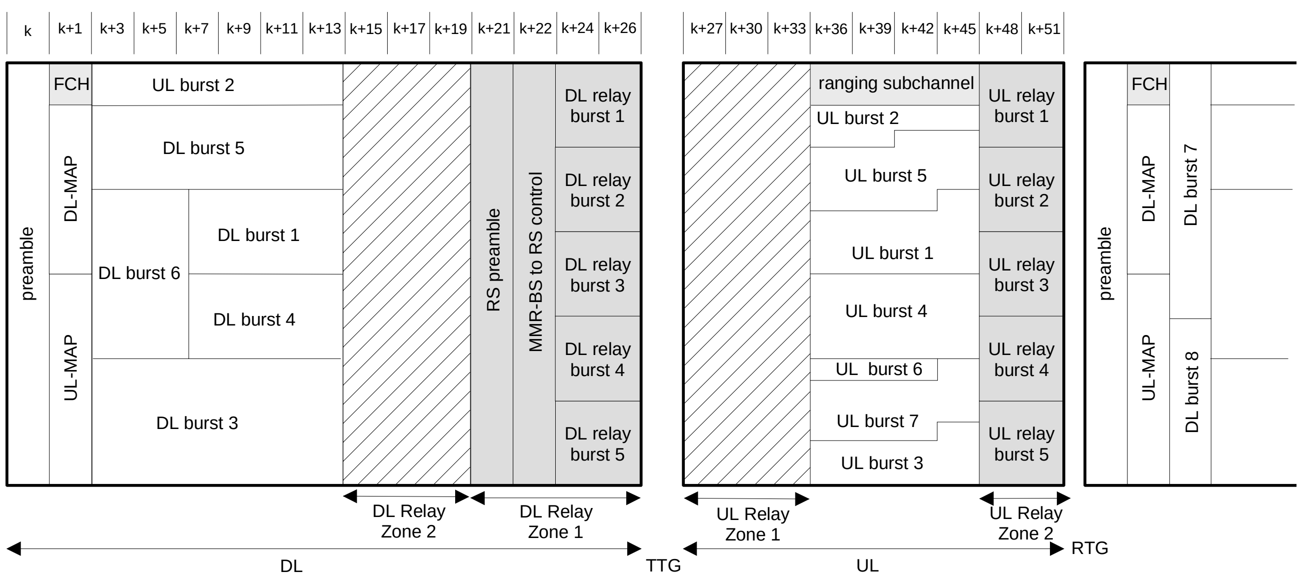

Figure 12. Frame Structure 2c from point of view of the MMR-BS (option 3)

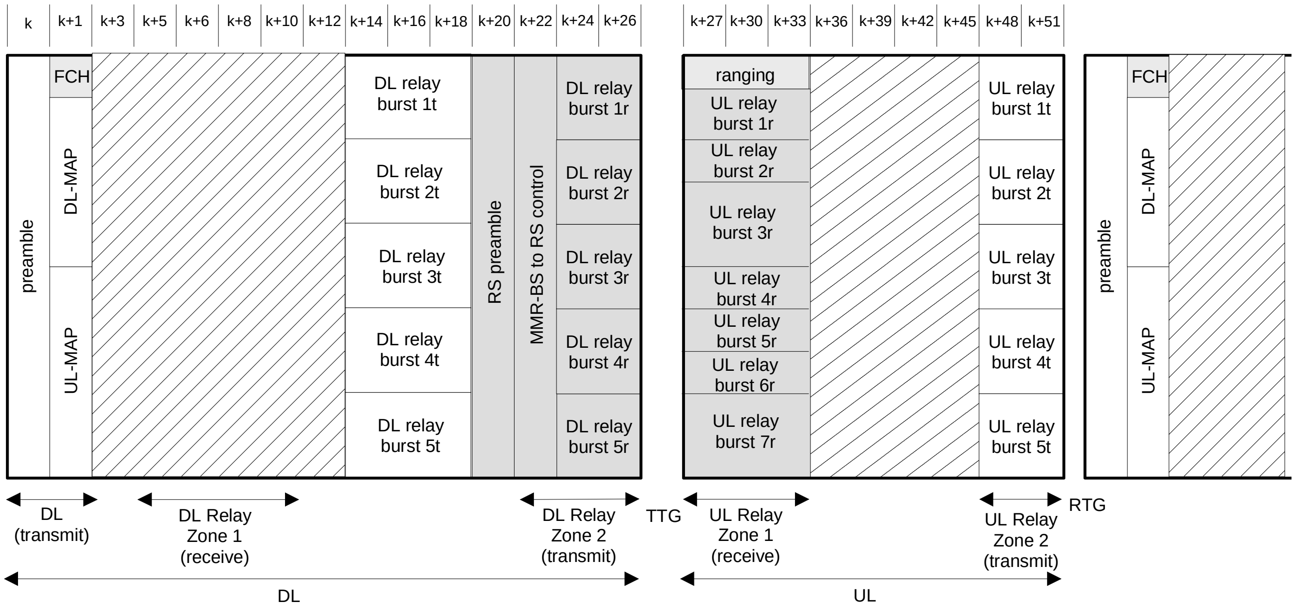

Figure 13. Frame Structure 2c from point of view of the RS (option 3).

Add Figure zzz below following Section 8.4.4.8.

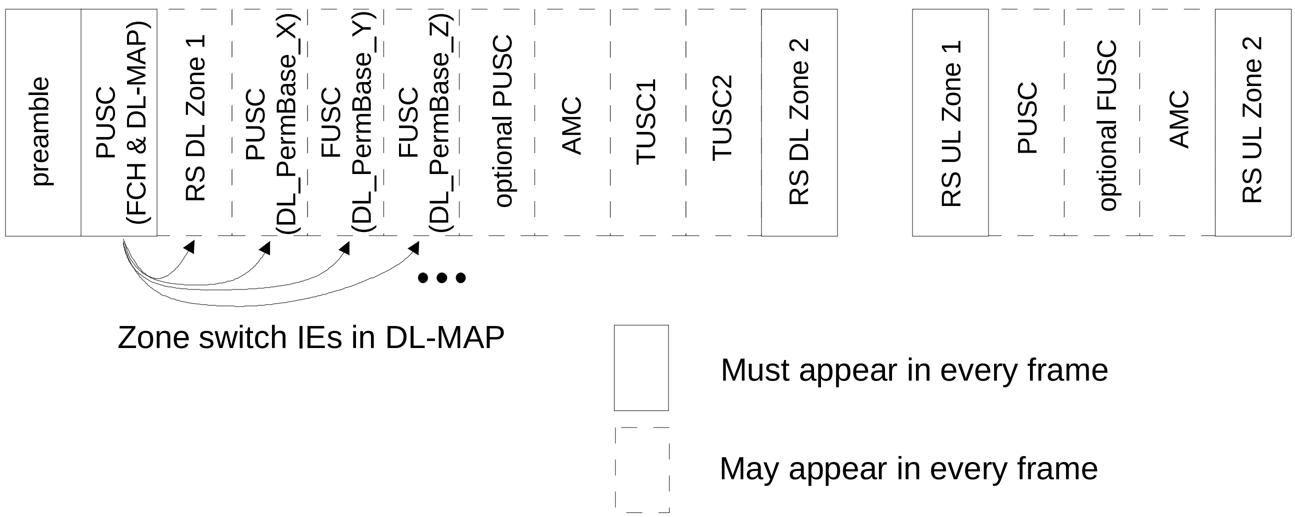

Figure zzz. Illustration of OFDMA relay frame with multiple zones

4 Proposed text for Insertion into Section 8.4.6.1 of IEEE 802.16j-06/026

Insert the following Section 8.4.6.1.2 immediately following Section 8.4.6.1.

8.4.6.1.2 RS Preamble

The RS preamble is the first symbol of the MMR-BS transmission to an RS during RS DL Zone 1. The RS preamble is defined similarly to the preamble defined in Section 8.4.6.1.1. The PN sequences used for the RS Preamble are designed to have minimum cross-correlation to the sequences defined in Tables 309 through 309d. The PN sequences defining RS preamble are defined in Tables 309R, 309aR, 309bR, and 309cR.

Table 309R. RS Preamble modulation series per segment and IDcell for the 2K FFT mode.

Index	**IDCell**	**Segment**	**Series to modulate (in hexadecimal format)**
0	0	0	TBR
1	1	0	TBR
2	2	0	TBR
3		0	TBR
…	…	…	…

31	31	0	TBR
32	0	1	TBR
33	1	1	TBR
24	2	1	TBR
…	…	…	…
63	31	1	TBR
64	0	2	TBR
65	1	2	TBR
66	2	2	TBR
…	…	…	…
95	31	2	TBR
96	0	0	TBR
97	1	1	TBR
98	2	2	TBR
99	3	0	TBR
100	4	1	TBR
101	5	2	TBR
102	6	0	TBR
102	7	1	TBR
104	8	2	TBR
105	9	0	TBR
106	10	1	TBR
107	11	2	TBR
108	12	0	TBR
109	13	1	TBR
110	14	2	TBR
111	15	0	TBR
112	16	1	TBR
113	17	2	TBR

Table 309aR. RS Preamble modulation series per segment and IDcell for the 1K FFT mode.

Index	**IDCell**	**Segment**	**Series to modulate (in hexadecimal format)**
0	0	0	TBR

1	1	0	TBR
2	2	0	TBR
3		0	TBR
…	…	…	…
31	31	0	TBR
32	0	1	TBR
33	1	1	TBR
24	2	1	TBR
…	…	…	…
63	31	1	TBR
64	0	2	TBR
65	1	2	TBR
66	2	2	TBR
…	…	…	…
95	31	2	TBR
96	0	0	TBR
97	1	1	TBR
98	2	2	TBR
99	3	0	TBR
100	4	1	TBR
101	5	2	TBR
102	6	0	TBR
102	7	1	TBR
104	8	2	TBR
105	9	0	TBR
106	10	1	TBR
107	11	2	TBR
108	12	0	TBR
109	13	1	TBR
110	14	2	TBR
111	15	0	TBR
112	16	1	TBR
113	17	2	TBR

Table 309bR. RS Preamble modulation series per segment and IDcell for the 512 FFT mode.

Index	IDCell	Segment	Series to modulate (in hexadecimal format)
0	0	0	TBR
1	1	0	TBR
2	2	0	TBR
3		0	TBR
…	…	…	…
31	31	0	TBR
32	0	1	TBR
33	1	1	TBR
24	2	1	TBR
…	…	…	…
63	31	1	TBR
64	0	2	TBR
65	1	2	TBR
66	2	2	TBR
…	…	…	…
95	31	2	TBR
96	0	0	TBR
97	1	1	TBR
98	2	2	TBR
99	3	0	TBR
100	4	1	TBR
101	5	2	TBR
102	6	0	TBR
102	7	1	TBR
104	8	2	TBR
105	9	0	TBR
106	10	1	TBR
107	11	2	TBR
108	12	0	TBR
109	13	1	TBR
110	14	2	TBR
111	15	0	TBR
112	16	1	TBR

113	17	2	TBR

Table 309cR. RS Preamble modulation series per segment and IDcell for the 128 FFT mode.

Index	IDCell	Segment	Series to modulate (in hexadecimal format)
0	0	0	TBR
1	1	0	TBR
2	2	0	TBR
3		0	TBR
…	…	…	…
31	31	0	TBR
32	0	1	TBR
33	1	1	TBR
24	2	1	TBR
…	…	…	…
63	31	1	TBR
64	0	2	TBR
65	1	2	TBR
66	2	2	TBR
…	…	…	…
95	31	2	TBR
96	0	0	TBR
97	1	1	TBR
98	2	2	TBR
99	3	0	TBR
100	4	1	TBR
101	5	2	TBR
102	6	0	TBR
102	7	1	TBR
104	8	2	TBR
105	9	0	TBR
106	10	1	TBR
107	11	2	TBR
108	12	0	TBR
109	13	1	TBR

110	14	2	TBR
111	15	0	TBR
112	16	1	TBR
113	17	2	TBR