Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Frame structure for support of multihop relaying**
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Source(s)	Mike Hart Fujitsu Laboratories of Europe Ltd. Hayes Park Central Hayes, Middx, UB4 8FE, UK Voice: +44 20 8606 4523 Fax: +44 20 8606 4539 mike.hart@uk.fujitsu.com Dorin Viorel Fujitsu Microelectronics Canada Inc.
Re:	Call for technical proposals IEEE 802.16j-06/034.
Abstract	This contribution provides a text proposal that provides simple clarifications to the existing text in the baseline document that defines the two-hop in-band frame structure for the TDD mode of the OFDMA PHY to enable support for more than two-hop relaying. As a result of the proposed clarifications it will be possible to support extension to multihop via two different configurations. The first is via a superframe or multi-phase approach which involves defining one relay-zone per subframe and changing the structure of the frame at the RS and MR-BS based on the frame number. The second is via partitioning the subframe to contain two relay-zones and changing the RS frame structure with RS hop number. Both approaches have their relative merits, hence the contribution proposes that both configurations be supported so that the most appropriate one can be selected based on the operational scenario.
Purpose	For discussion and approval of inclusion of the proposed text into the P802.16j baseline document.
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Frame structure for support of multihop relaying

Mike Hart & Dorin Viorel
Fujitsu

Introduction

In order to enable the support of multi-hop (more than 2-hop) in-band relaying for non-transparent relays operating in the TDD mode of the OFDMA-PHY, modification to the current text in the baseline of the draft standard [1] is required to: define how the current 2-hop frame structure is extended to support multihop, which is used throughout this document to refer to the case of >2 hop relaying; rules of operation in terms of RS transmission and reception intervals; and also the rules that the RS and MR-BS must follow in order to allow for turn-around in the RS and SS transceivers.

This contribution starts by discussing the various approaches that could be adopted for a multihop supporting frame structure that is an extension to the 2-hop frame structure accepted in meeting #46 [2].

Overview of approaches proposed in meeting #46

Based on a summary of a number of the contributions introduced in meeting #46, there exist in general two approaches to extending the current two-hop frame structure to support multihop, they are:

- Construct a super-frame of multiple two-hop frames (referred to superframe approach from hereon)
  → Frame structure at RS and MR-BS changes with frame number
- Define at least two R-zones per subframe (referred to as the partitioning approach from hereon)
  → Frame structure at RS changes with RS hop number (no change of MR-BS frame structure)

Super-frame approach

In short a super-frame is defined that consists of a number of MR-BS or RS frames. This allows support of multihop relaying with a minimum of one relay zone per subframe by changing the usage of the relay zone at the RS between transmission and reception across frames or superframes (i.e. the usage of the relay zone in either the DL or UL subframe is different for odd and even frame numbers [3] or alternates across consecutive superframes [4]).

Partitioning approach

In short the subframe is partitioned into a minimum of one access and two relay zone intervals (as opposed to one access and one relay zone interval for two-hop case). The usage of the relay zones at the RS remains the same across the frames, however in the minimal case of two relay zones, whether a zone is used for transmission or reception alternates with increasing hop number [5] [6] [7].

Comparison

Both approaches have relative advantages and disadvantages and it is likely that in reality the best approach will depend on a combination of QoS requirements, buffering capabilities at MR-BS and intermediate RSs, frame size and DL to UL subframe ratio (or the number of OFDMA symbols in the subframe).

For example, in the case of small frame sizes or extremely asymmetric subframe ratios the partitioning approach may result in unreasonably small access and/or relay zone durations in one or both subframes. However, in the case of larger frame sizes the superframe approach could result in long superframe sizes causing unnecessarily large latency and buffering requirements as well as impacting adaptive link control on the relay link or on the access link in the case of centralized scheduling. Thus neither approach provides a solution that is optimal for all scenarios.

Proposed Multi-hop Frame Structure

This proposal defines a simple extension to the two-hop frame structure in [2] that enables the frame structure to remain configurable and support multihop by either one of the two approaches outlined above. Note it only goes as far as dealing with the subframe structure and does not consider the content or structure of relay zone within the subframe, this is out-of-scope of this contribution. However, a separate proposal for the relay zone structure is provided in [8].

At present, the TDD frame structure in the standard divides the frame into two subframes for downlink and uplink transmission. To enable two-hop relaying the baseline currently defines a minimum of one R-zone per subframe in addition to one access zone per subframe. Thus the baseline already in part supports the partitioning approach due to the fact multiple relay zones can be configured in a subframe. However, one clarification is required to enable support for both the partitioning and superframe approach and this is to define that a relay link interval in either the DL or UL subframe can be configured to be used for either transmission or reception, but not both, to facilitate MR-BS to RS and RS to RS communication.

Once this is defined it is possible to construct a logical superframe from numerous MR-BS or RS frames of any number of relay zones. No normative text is required to define this based on the clarified version of the existing text, as it is purely an implementation and configuration issue which can be clarified once the signaling support for frame structure is considered to ensure that appropriate signaling is in place.

However, to make sure both concepts are captured as the standard develops, an example of supporting multihop by both approaches is included. Consequently this keeps the changes to the existing text in the baseline simple, but enables configuration of a system in the most appropriate mode, based on the operational issues discussed earlier in this contribution.

As a result of this text proposal, the SS still obeys the frame structure as defined in IEEE 802.16-2004 and the MR-BS as defined in the baseline document [1]. Within the DL subframe, the RS may operate in either transmit or receive mode, but not both, in any one relay link interval to receive communications directed in a forward direction from an MR-BS or RS, or transmit signals to other RS in a forward direction. Likewise, in the UL subframe, the RS may operate in either transmit or receive mode, but not both, in any one relay link interval to receive communications directed in a reverse direction from an RS or transmit signals to another RS or MR-BS in a reverse direction. Thus the RS will never be required to perform simultaneous transmission and reception within the same zone. Every time the RS transitions between transmit and receive a transition gap must be allowed for between the adjacent zones with different transceiver operational mode.

Advantages of the proposal

The benefit of this approach and the associated proposed text is that it enables the frame structure to remain configurable so that the chosen configuration can be optimized based on the operational requirements, as discussed. Whilst the proposed text enables flexibility, and hence could incur unnecessary complexity, it could be possible to define optimal configurations in the form of RS system profiles at a later date for particular usage scenarios. Ultimately, the flexibility enables this choice to be left to the network operator and service provider to adopt the most suitable configuration accordingly with the operational requirements (i.e. number of expected hops, frame size, subframe ratio, etc).

Furthermore, the change to the existing two-hop frame structure from the RS perspective is minimal in that the RS is now required to support either transmission or reception, but not both, within one relay link interval.

Conclusion

This proposal provides a simple extension to the existing TDD frame structure defined in the baseline document that enables support for beyond two-hop in-band non-transparent relaying. The proposed text effectively allows

the system to be configured to support either the super-frame or partitioning approach, assuming that the necessary signaling support is included at a later date. Consequently, maximum flexibility is provided in terms of multihop support with minimal PHY impact.

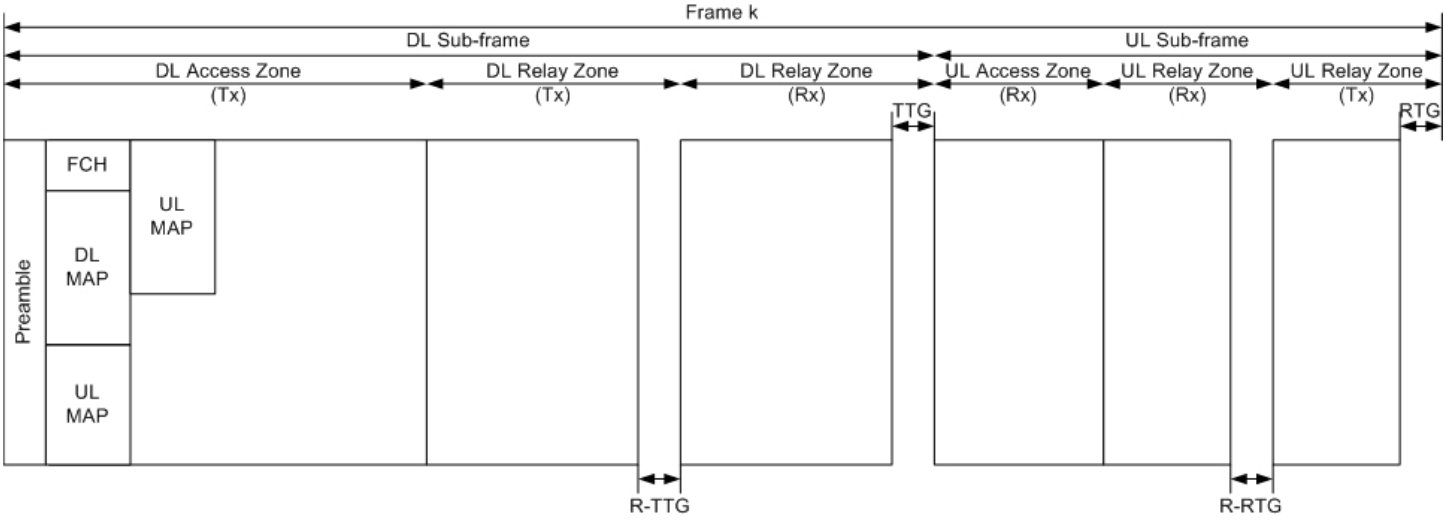
Proposed text changes

[Change subclause 8.4.4.7.2.2 as indicated]

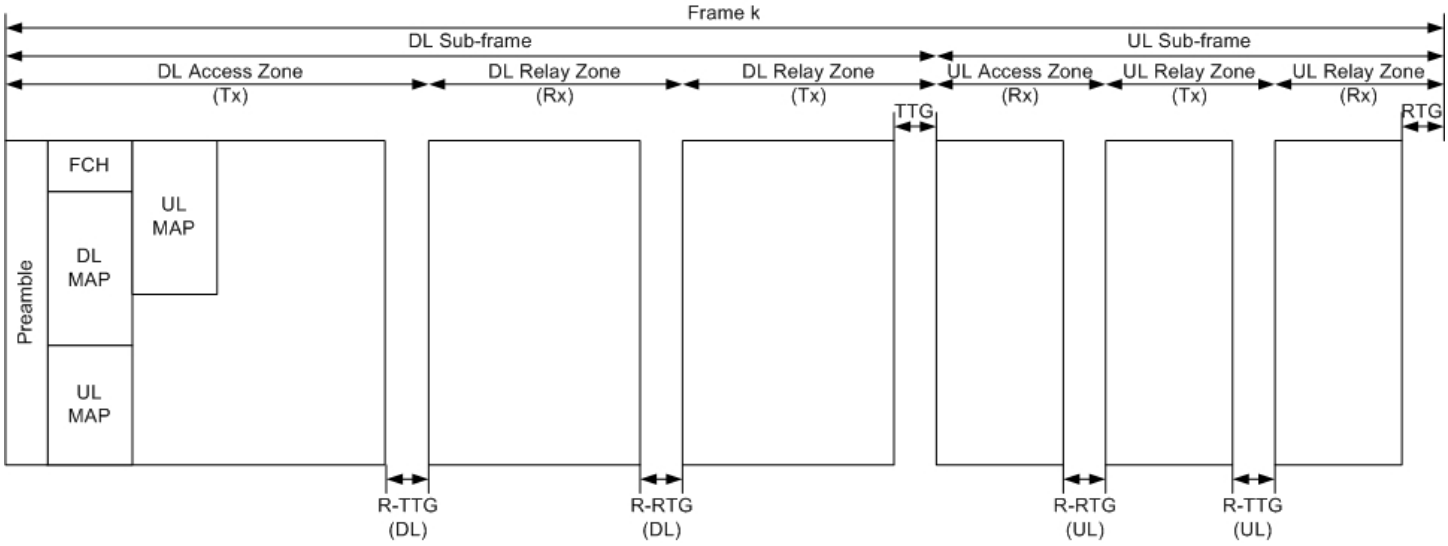
8.4.4.7.2.2 Relay frame structure

For the TDD mode, an example of an RS frame structure for two-hop relaying is shown in Figure <xxx>. Two methods for supporting more than two hop relaying are defined. An RS shall be capable of being configured to support either one of the methods, but shall not be required to support both simultaneously. The first approach uses different two-hop RS frame structures at an odd and even hop numbered RS, as illustrated in Figure <xxx> (a) and (b) for an odd hop number and even hop number RS, respectively. The second approach uses different two-hop RS frames structures at an RS for odd and even frame numbers, as illustrated in Figure <xxx+1> (a) and (b) for an odd frame number and even frame number, respectively.

Figure <xxx>—Example 1 of minimal configuration (subframe partitioning approach) for an in-band non-transparent relay frame structure for more than two-hop communication for (a) odd hop number RS; (b) even hop number RS.

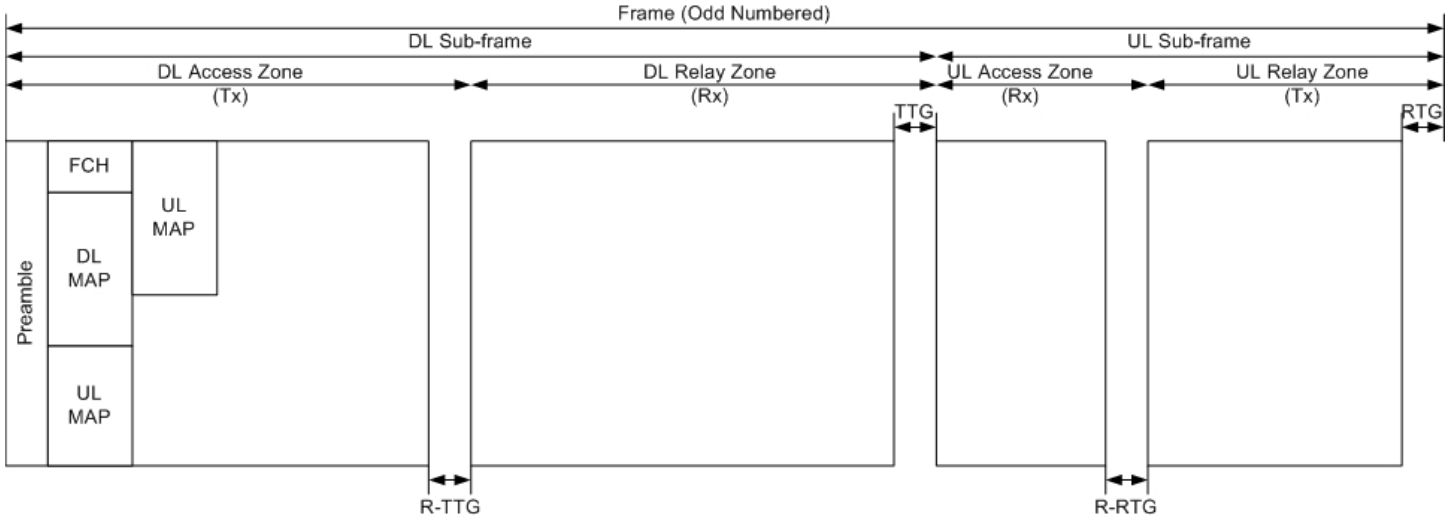


(a)

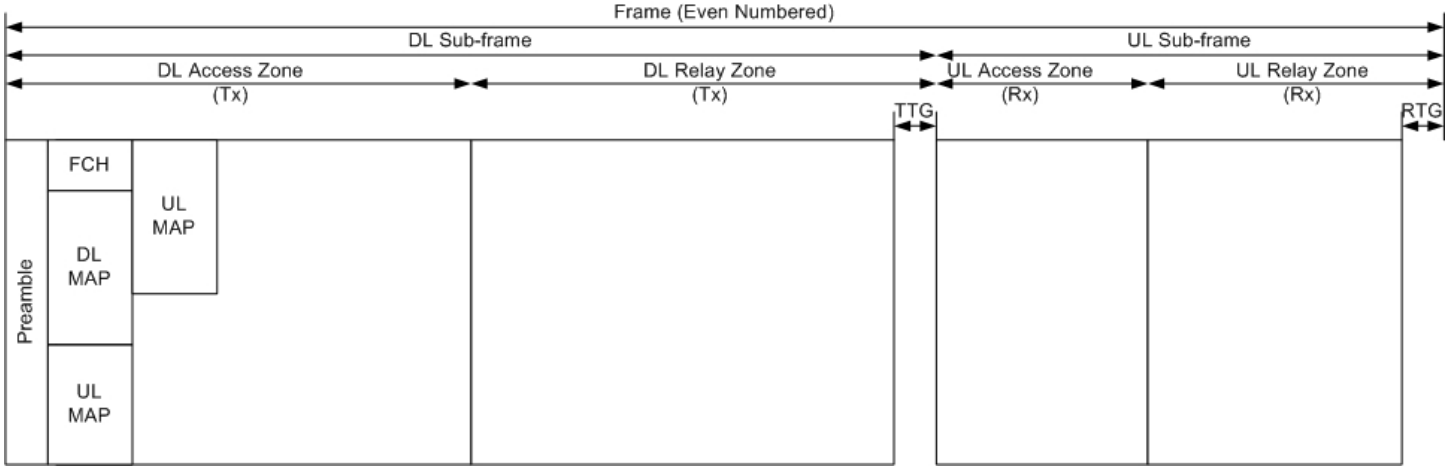


(b)

Figure <xxx+1>—Example 2 of minimal configuration for an in-band non-transparent relay frame structure (super-frame approach) for more than two-hop communication for (a) odd frame number; (b) even frame number.



(a)



(b)

The DL sub-frame shall include at least one DL Access_Zone and may include one or more DL Relay_Zones. An R-TTG may be placed between a DL Access_Zone and a DL Relay_Zone and an R-TTG or R-RTG may be placed between two adjacent DL Relay_Zones.

The UL sub-frame may include one or more UL Access_Zones and one or more UL Relay_Zones. An R-RTG may be placed between a UL Access_Zone and a UL Relay_Zone and an R-TTG or R-RTG may be placed between two adjacent UL Relay_Zones.

A relay zone may be utilized for either transmission or reception but the RS shall not be required to support both modes of operation within the same zone.

If the relay station switches from transmission to reception mode, an R-TTG shall be required. If the relay station switches from reception to transmission mode, an R-RTG shall be required. There may be more than one R-TTG and more than one R-RTG inserted in the RS frame. In each frame, the TTG shall be inserted between the DL sub-frame and the UL sub-frame. The RTG shall be inserted at the end of each frame.

The contents of the FCH, DL-MAP and UL-MAP in the Relay Frame may be different from those in the MR-BS frame.

Each RS frame begins with a preamble followed by an FCH and the DL-MAP and possibly a UL-MAP. In the DL Access_Zone, the subchannel allocation, the FCH transmission, and the FCH shall be as defined in Section 8.4.4.2.

The number, size, and location of the relay zones and whether the RS is utilizing the zone for transmission or reception shall be configurable.

Remove new subclause 8.4.4.8:
~~8.4.4.8 Relaying frame structure~~

References

[1] IEEE 802.16 Relay TG, “Baseline Document for Draft Standard for Local and Metropolitan Area Networks Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems: Multihop Relay Specification”, IEEE 802.16j-06/026r1, 1 December 2006.
[2] Chenxi Zhu et al., “Frame Structure to Support Relay Node Operation”, IEEE C802.16j-06/233r8, 16 November 2006.
[3] Youngbin Chang et al., “Frame Structure for multi-hop relay”, IEEE C802.16j-06/257, 7 November 2006.
[4] Wendy Wong et al., “Multi-phase Frame Structure Proposal”, IEEE C802.16j-06/275, 7 November 2006.
[5] Mike Hart et al., “Frame structure for multihop relaying support”, IEEE C802.16j-06/138, 7 November 2006.
[6] Hang Zhang et al., “Frame Structure to Support Relay Node Operations”, IEEE C802.16j-06/233r1, 6 November 2006.
[7] Roger Peterson et al., “Proposal for Multihop Relay Frame Structure for 802.16j”, IEEE C802.16j-06/155, 7 November 2006.
[8] Mike Hart et al., “Relay zone structure definition”, IEEE C802.16j-07/xxx, xx January 2007.