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Source(s)	Wendy C Wong wendy.c.wong@intel.com Jerry Sydir jerry.sydir@intel.com Hannah Hyunjeong Lee Kerstin Johnsson	Intel Corporation 2200 Mission College Blvd., Santa Clara, CA 95054, USA
	Roger Peterson r.peterson@motorola.com Eugene Visotsky	Motorola Labs 1301 E. Algonquin Road, Schaumburg, IL 60196
	Masahito Asa asa@motorola.com	Motorola Japan Ltd., 3-20-1 Minamiazabu, Minatoku, Tokyo, 106-8573, Japan
	Fang-Ching Ren frank_ren@itri.org.tw I-Kang Fu IKFu@ITRI.ORG.TW	National Chiao Tung University/Industrial Technology Research Institute 1001 Ta Hsueh Road, Hsinchu, Taiwan 300, ROC
	Mike Hart mike.hart@uk.fujitsu.com	Fujitsu Laboratories Europe Hayes Park Central Hayes, Middx, UB4 8FE, UK
	Dorin Viorel dviorel@fmci.fujitsu.com	Fujitsu Microelectronics Canada Inc.#300., 2710-17th Ave SE, Calgary, AB T2A0P6, Canada
	Wen Tong wentong@nortel.com	Nortel 3500 Carling Ave. Ottawa, On, K2H 8E9 Canada
	David Comstock dcomstock@huawei.com John Lee, Zheng Shang	Huawei Technologies No.98, Lane91, Eshan Road, Shanghai, P.R.C Voice: +1 858 735 9382
	Koon Hoo Teo teo@merl.com Jeffrey Tao Jinyun Zhang	Mitsubishi Electric Research Lab Address: 201 Broadway Cambridge, MA 02421, USA voice: 617 621 {7527, 7557, 7595} Fax: 617 621 7550

	Toshiyuki Kuze	Mitsubishi Electric Corp 5-1-1 Ofuna Kamakura, Kanagawa 2478501, Japan
	Changyoon Oh, Youngbin Chang, Mihyun Lee, HyoungKyu Lim, Jaeweon Cho, Panyuh Joo	Samsung Electronics 416, Maetan-3dong, Youngtong-gu, Suwon-si, Gyeonggi-do, Korea
	Rakesh Taori	Samsung Advanced Institute of Technology

Re:	This is a response to the call for proposals 80216j-06_034.pdf.
Abstract	This contribution propose a frame structure to support multi-hop (>= 2 hops) relay operation.
Purpose	Text proposal for 802.16j Baseline Document.
Notice	
Release	
Patent Policy and Procedures	

Frame Structure to Support Multi-hop Relay Operation

1 Introduction

The frame structure proposal accepted into the working document in the Dallas meeting addresses the case of in-band relay for two hop only networks. It provides a good basis for the frame structure required to support in-band and out-of-band relay in multi-hop networks.

This contribution proposes the additional constructs required to support multi-hop topologies. We define multi-hop topologies to be topologies where the number of hops between the MR-BS and an MS can be 2 hops or larger. Our proposal builds on the configurable frame structure that was defined in the Dallas meeting.

1.1 Support for Multiple Hops

When the topology of an MR network spans more than two hops, some RSs are required to receive from the MR-BS or a parent RS and to transmit to a child RS. In order to support this scenario at least two DL Relay_Zones and two UL Relay_Zones are required to prevent RSs from having to transmit and receive within the same Relay_Zone.

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 multi-frame of multiple two-hop frames (referred to multi-frame approach from hereon). In this approach the 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). In this approach the frame structure at RS changes with RS hop number (no change of MR-BS frame structure)

Multi-frame approach
In short a multi-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 MR-BS and RSs between transmission and reception across frames within the multi-frame The multi-frame represents a recurring pattern that occurs in time. For example, a two frame multi-frame represents a two-frame odd-even pattern. When the MR-BS is assigned to transmit in the DL Relay_Zone in the first frame of a two-frame multi-frame, the MR-BS is effectively assigned to transmit in the DL Relay_Zone of even number frames. The multi-frame approach accommodates better the small size frames.

Partitioning approach
In short the subframe is partitioned into a minimum of one access and two relay zones (as opposed to one access and one relay zone 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. The partitioning approach provides an optimized delay for multi-hop transmissions for the case where the frame size is large enough to accommodate two relay zones.

Both approaches provide backwards compatibility with the basic frame structure proposed during the IEEE802.16 session #47 meeting.

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 asymmetrical 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 multi-frame approach could result in long multi-frame sizes causing unnecessarily large latency and buffering requirements as well as impacting adaptive link control on the relay link or on the access link.

1.2 Support for mobile RS (MRS) handover

In order to support MRS in a multi-hop environment, additional synchronization channels (pre- or post-ambles) are required. A synchronization channel is required for each DL Relay_Zone in order to allow an MRS to synchronize with the DL subframe of a Relay_Zone of a RS or MR-BS. The Frame Start Preamble for the access link cannot be used for this purpose because an RS cannot transmit and receive at the same time. An RS is required to transmit the frame start preamble for its MSs at the start of every frame in order to maintain backwards compatibility. Requiring an MRS to perform synchronization with a RS/MR-BS using this frame start preamble would require that MRS to receive the frame start preambles of the RS/MR-BS while simultaneously transmitting a frame start preamble to its access MS. Hence, a relay preamble or postamble that is orthogonal in time to the frame start preamble is needed to support MRS.

2 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.
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 multi-frame approach and this is to define
that a relay link zone in either the DL or UL subframe can be configured to be used for either transmission or reception, but not both, to enable MR-BS to RS and RS to RS communication.

Once this is defined it is possible to construct a logical multi-frame from numerous MR-BS or RS frames of any number of relay zones.

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. The MR-BS and RSs are assigned to either transmit, receive, or be idle in each DL relay zone. Likewise, the MR-BS and RSs are assigned to either transmit, receive or be idle in each UL Relay zone. 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.

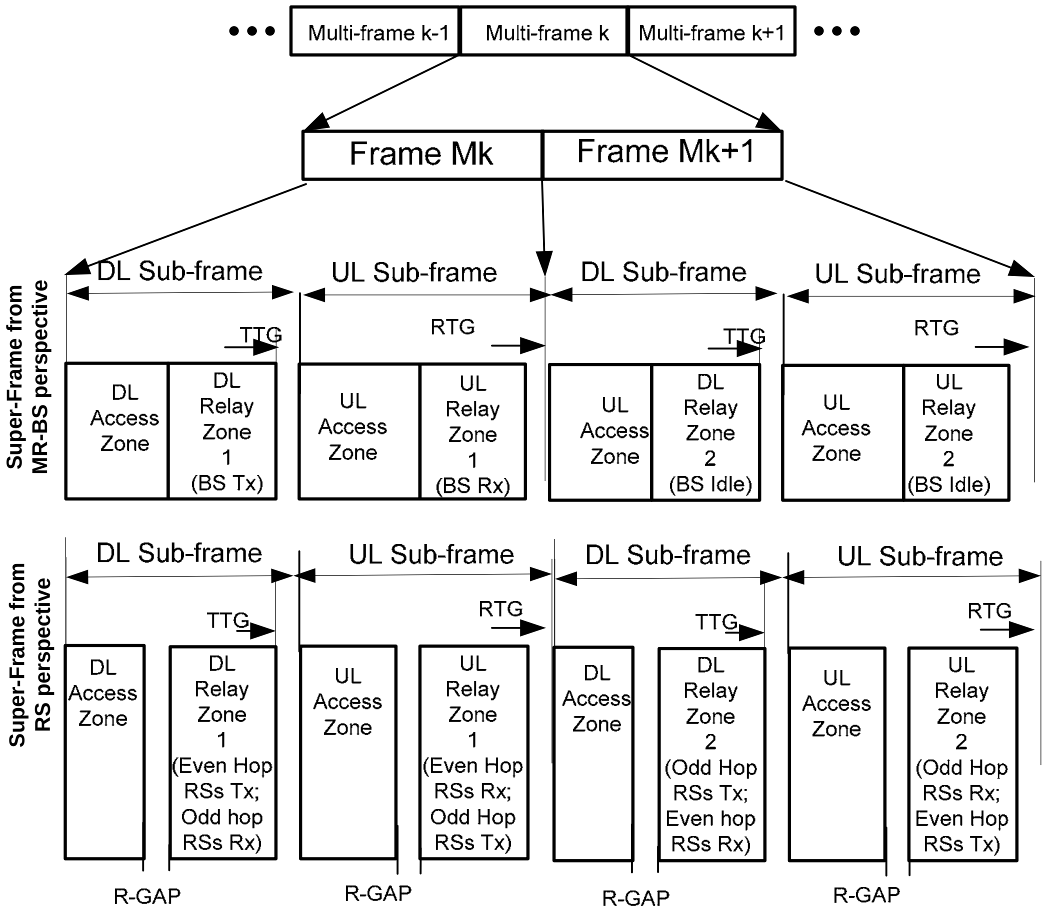
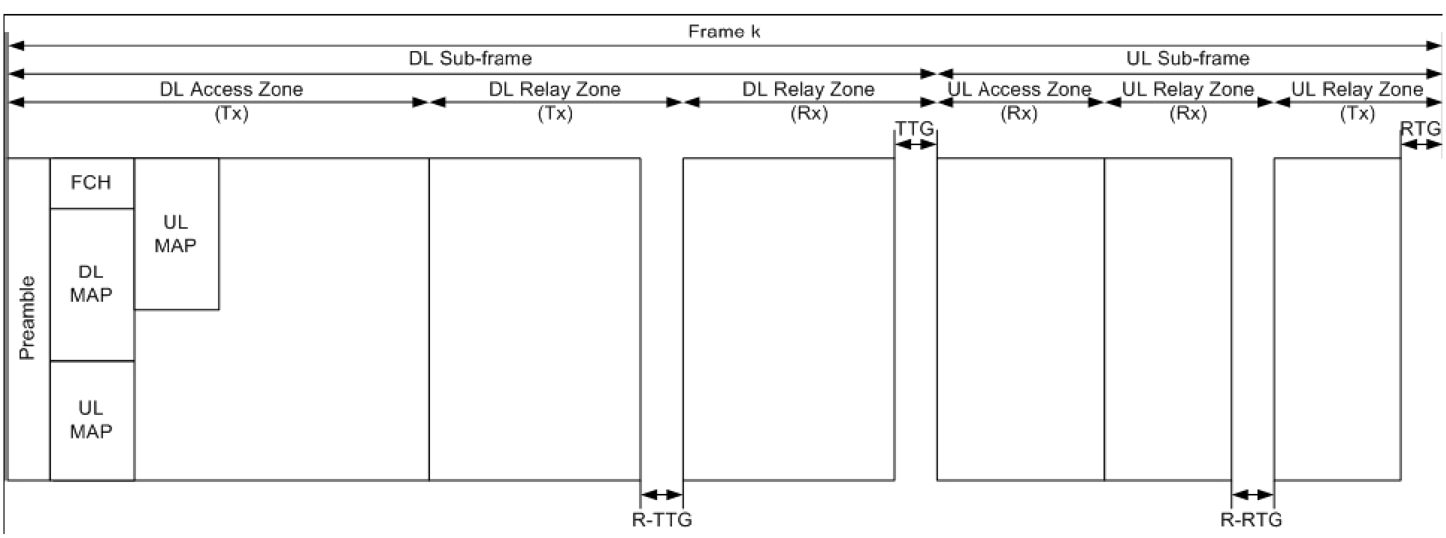


Figure 1. Example Multi-frame structure.



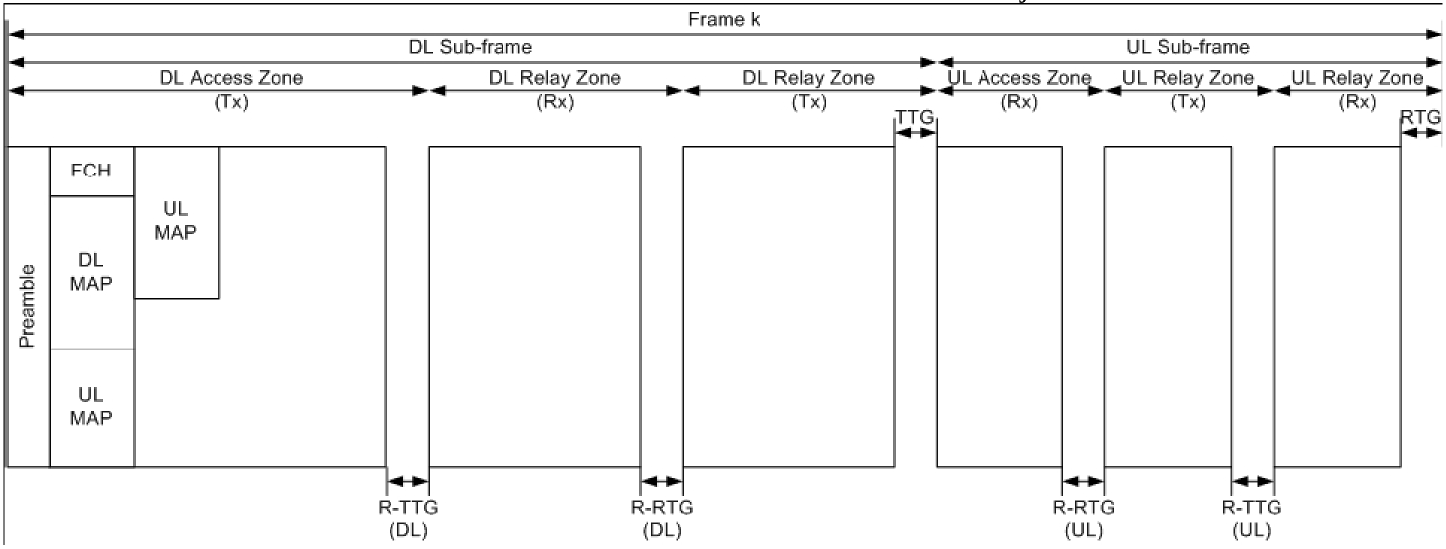


Figure 2. Example Multi-hop frame structure based on the partitioned approach

2.1 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 zone.

2.2 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 multi-frame or partitioning approach, assuming that the necessary signaling support is included at a later date.

3 Proposed text changes

++++++++++++ start text proposal ++++++++++++++++++++++++++++++++++

[Remove the following text from the end of the subclause 6.3.7.2 and move it to section 8.4.4.7.2:]
~~For the case where MR-BS supports two-hop relay, the DL and UL subframes shall include at least one access zone and may include one or more relay zone to enable RS operating in either transmit or receive mode. The related frame structure is defined in the OFDMA PHY specific section.~~

[Add the following text (moved from the end of the subclause 6.3.7.2) to the beginning of section 8.4.4.7.2:]

For the case where MR-BS supports two-hop relay, the DL and UL subframes shall include at least one access zone and may include one or more relay zone to enable RS operating in either transmit or receive mode.

[Add the following text to the beginning of subclause 8.4.4.7.2 after the text moved from subclause 6.3.7.2]
Two approaches for supporting more than two hop relaying are specified. An RS shall be capable of being configured to support either one of the operations, but shall not be required to support both operations simultaneously.

The first approach allows one or more RS or MR-BS frames to be grouped into a multi-frame with a repeating pattern of allocated relay zones. The MR-BS and RSs are assigned to transmit, receive or be idle in each of the relay zones within the multi-frame. As an example, a two-frame multi-frame can be used to assign odd hop RSs to transmit in the DL Relay Zone of odd number frames and the MR-BS and even hop RSs to transmit in the DL Relay Zone of even number frames.

The second approach enables a single-frame frame structure consisting of more than one Relay zones. The MR-BS and RSs are assigned to transmit, receive, or be idle in each relay zone within the frame.. As anexample, the odd hop RSs can be assigned to transmit in one DL Relay Zone, while the MR-BS and even op RSs can be assigned to transmit in another DL relay zone.

[Change subclause 8.4.4.7.2.1 as indicated]

Each MR-BS frame begins with a preamble followed by an FCH and the DL MAP and possibly UL MAP. The DL sub-frame shall include at least one DL Access Zone and may include one or more DL Relay_Zones. The UL sub-frame shall include at least one UL Access Zones and it may include one or more UL Relay_Zones. A relay zone may be utilized for either transmission or reception but the MR-BS shall not be required to support both modes of operation within the same zone. 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. In the DL Access Zone, the subchannel allocation, the FCH transmission, and the FCH shall be defined as in Section 8.4.4.2.

[Change subclause 8.4.4.7.2.2 as indicated]
8.4.4.7.2.2 Relay frame structure

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 inserted 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~~ may be required. If the relay station switches from reception to transmission mode, an R-RTG ~~shall~~may 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 MRBS 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 relay zone for transmission or reception shall be configurable. The number of frames that make up a multi-frame shall be configurable.

++++++++++++++++++++ *End of text proposal* ++++++++++++++++++++++