Project	**IEEE 802.16 Multihop Relay Project < http://ieee802.org/16/relay/index.html >**
Title	**Dynamic Frame Structure for IEEE802.16j Relaying Transmission to Support Efficient Scheduling**
Date Submitted	**2006-11-07**
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Re:	This is a response to a Call for Technical Proposal regarding IEEE Project P802.16j issued on 24th October 2006 http://ieee802.org/16/relay/docs/80216j-06_027.pdf
Abstract	This document propose a frame structure to support fractional frequency reuse for 802.16j relaying mode.
Purpose	A partial technical proposal submitted IEEE 802.16j TG for considerations and further discussions.
Notice	
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Patent Policy and Procedures	

Dynamic Frame Structure for IEEE802.16j Relaying Transmission to Support Efficient Scheduling

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Introduction

This document proposes a dynamic frame structure for 802.16j relay transmission in order to provide support for efficient scheduling. This contribution is a response to Call for Technical Proposal of IEEE802.16j which was issued on 24th October 2006. This document contributes one of the several possible frame structures for relay mode to Sections '8.4.4 Frame structure' and '8.4.4.8 Relaying frame structure' in the ToC. Other related sub sections are '6.3.5 Scheduling Services' and its followed sub sections. Therefore, in this document, we will start with a discussion on the 802.16e scheduling service and follow it with a proposed frame structure to support relay mode for high efficient relay transmissions.

MAC Scheduling service

As it is stated clearly in [1], scheduling services represent the data handling mechanisms supported by the MAC scheduler for data transport for a connection. Each connection is associated with a single scheduling service. Furthermore, a scheduling service is determined by a set of QoS parameters that quantify aspects of its behavior. These parameters are managed using the DSA and DSC message dialogs.

This might require 802.16j to make a clear definition of 'each connection' – each connection can be defined in the follow four categories for the relay mode:

- End-to-end connection: the connection is only defined on BS/MR-BS to MS(s).
  For this definition, only a single scheduling service (as defined) is required for BS/MR-BS to MS(s) including any RS(s) with any hops between BS/MR-BS and MS(s). However it excludes any possible scheduling on RS(s) if RS(s) have high-level functions.
- MR-BS to RS connection: the connection is defined for the connection between MR-BS to RS(s).
  This definition can be easily applied if the MR-BS treat a RS as a MS and then it is the exactly same that that defined in 802.16e.
- RS to MS connection: the connection is defined for the connection between RS to MS(s).
  This definition will authorize a RS to schedule its connection with its MS(s)
- RS to RS connection: the connection is defined for the connection between RS to RS(s).
  This definition will authorize a RS to schedule its connection with other RS(s).

According to the technical requirement [2], it requires that the specification shall provide signaling to support MAC scheduling of data and control message transmission on relay and access links (M9) and its mandatory for both MR-BS and RS. Also, it is noted that the scheduling may be centralized, distributed, or a hybrid thereof. Consequently, the four categories of the definition of 'connection' are proposed to be well-defined in 6.3.5.

The mobile WiMAX scheduling service is designed to efficiently deliver broadband data services [3]. In general, the scheduler must efficiently allocate available resources in response to data traffic and mobile channel conditions. For 802.16e, the scheduler is located at each base station to enable rapid response to traffic and channel. Also the scheduling service is provided for both DL and UL traffic, based on feedback by UL in TDD mode. Furthermore, the scheduler supports dynamic resource allocation on a per-frame basis.

For 802.16j, firstly we propose to have a clear definition of ‘available resources’ in response to data traffic and mobile channel conditions. Secondly, we propose to give a clear statement if 802.16j allows a scheduler located at each BS and each RS. Thirdly, we propose to allow a scheduler located at each RS. In case the scheduling service is out of the scope of 802.16j, say we use all scheduling services defined in 802.16j, we still need these kind of definitions/options for later manufacture’s decisions.

Relaying frame structure

The 802.16e PHY supports TDD and Full and Half-Duplex FDD operation. However, the initial release of Mobile WiMAX certifications profiles will only include TDD. For 802.16j, we propose to consider both TDD and FDD even though this document focuses on TDD.

For TDD, the defined frame structure of 802.16e is shown in Figure 1 (a). For clearer description in latter context, we make a simplified frame structure as shown in Figure 1 (b). However these two are exactly same in their functionality.

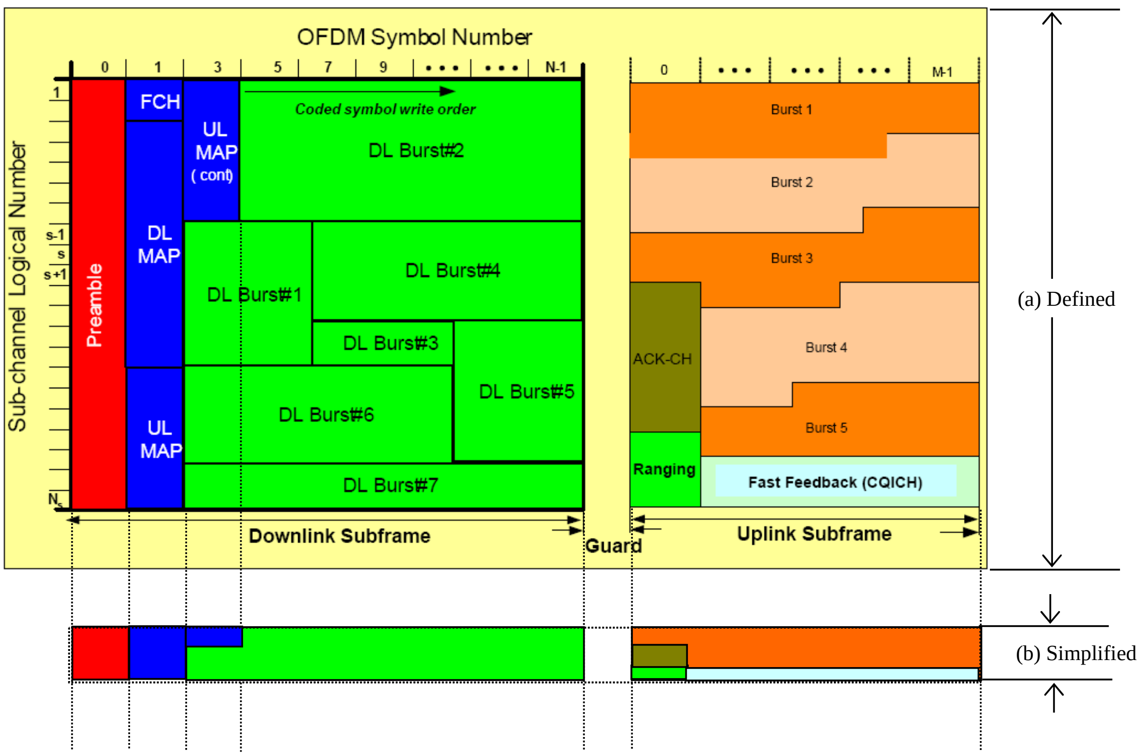


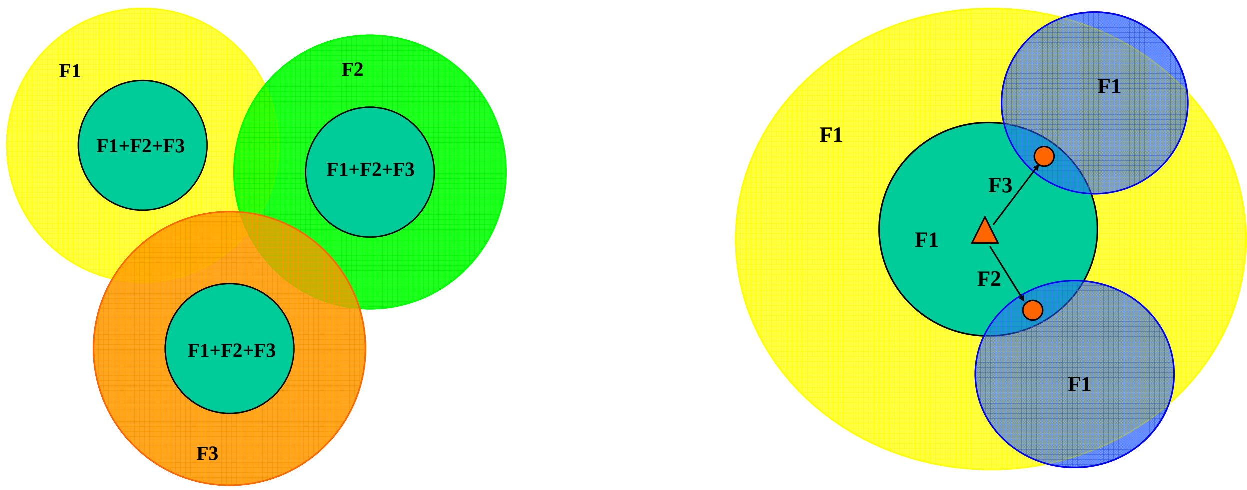
Figure 1: IEEE 802.16e defined frame structure and simplified frame structure

In order to support relay mode, the time-slot, for either downlink (DL) or uplink (UL), has to be split into segments to support BS to RS and segments to support RS to MS. In general, for multi-hop with *n* hops, the whole frame length, for either DL or UL should be divided by *n*. Here we use 2-hop relay for discussion as 2-hop is mandatory for 802.16j [2] (any hop-number greater than 2 is optional).

In a 2-hop relay, the frame is split into two parts. For the DL, the first part is supporting MR-BS to RS, and the second part is supporting RS to MS(s). Here, in order to distinct two different MSs, we introduce a new term ‘relayed MS (RMS)’, which is defined as a MS connecting to a RS (so, the second part is supporting RS to RMS(s)). Bear in mind that the legacy compatibility should be applied to both parts. The main reason for this is its TDD aspect of transmission:

- We claim that the first part is supporting MR-BS to RS, which implies that the MR-BS is not limited to transmit to RS. Therefore, it is possible for MR-BS to make partial transmission to RS and partial transmission to MSs other than RMSs.
- The RMS(s) might not be able to directly communicate with the MR-BS, therefore in this case, the RS must be treated as a BS and must be kept legacy compatible.

Furthermore referred to the fractional frequency reuse supported by 802.16e [4] as shown in Figure 2 (a). Since in WiMAX, users operate on sub-channel on sub-channel, it supports reconfiguration of the sub-channel usage without resorting to traditional frequency planning, and, the flexible sub-channel reuse is facilitated by sub-channel segmentation and permutation zone. With an extension of this concept and being fully compatible with 802.16e, 802.16j should support a similar fractional frequency reuse as shown in Figure 2 (b).



(a) Fractional frequency reuse with mobile WiMAX [4]   (b) Fractional frequency reuse with multihop relay

Figure 2: Fractional frequency reuse with 802.16e and 802.16j

With all these considerations and definitions, a dynamic frame structure is proposed as shown in Figure 3, where it shows that any connection to MS(s) or RMS(s) is always legacy compatible. More specifically, to any MS(s) in the network, there is no difference between 802.16e and 802.16j.

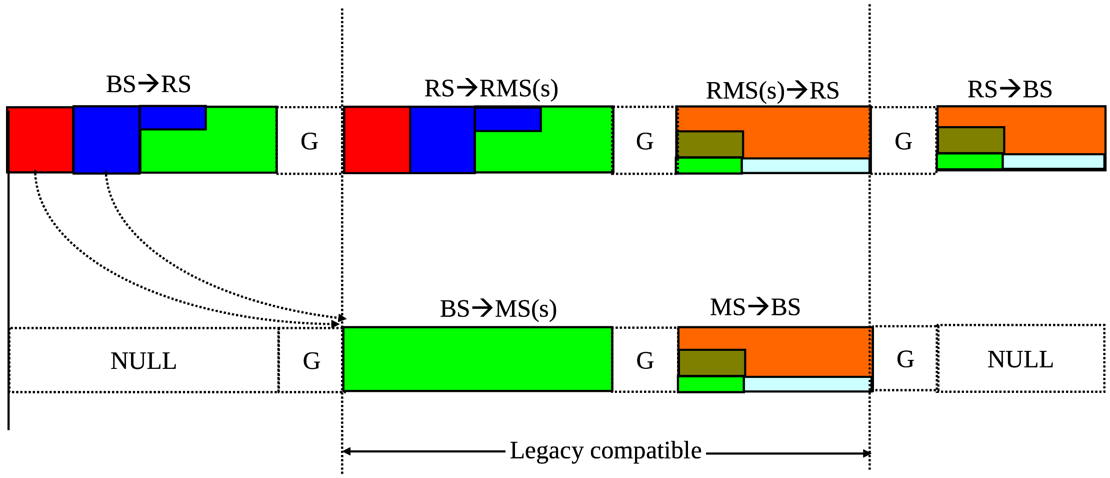


Figure 3: Proposed dynamic frame structure for 802.16j relay mode

Note that the frame structure as shown in Figure 3 is only for one relay link as BS→RS→RMS(s). Each part of the frame can be dynamically allocated, such as different length to support different connection’s configurations. This frame structure is suitable for either RMS be able to communicate with BS or not be able to. However, it the RMS is able to communicate to BS and controlled by the BS, an alternative frame structure can also be applied as shown in

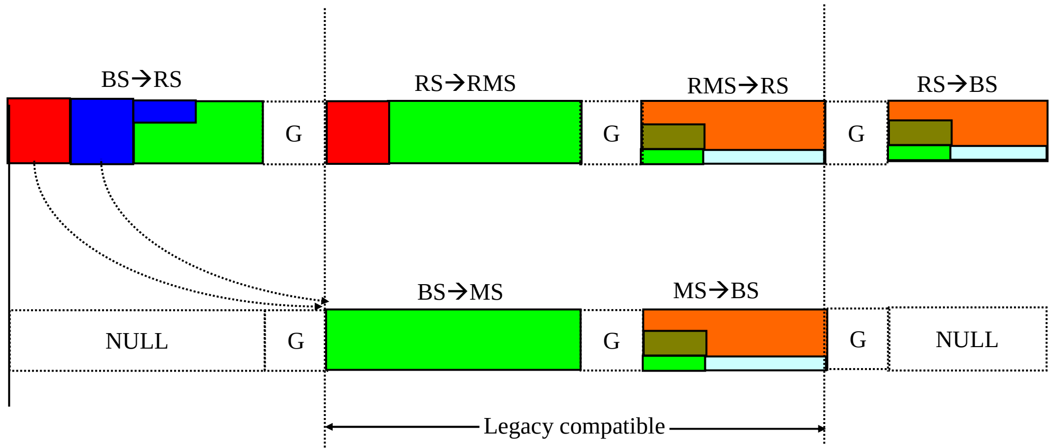


Figure 4: Alternative frame structure for BS directly communicate with RMS(s)

However, for the application of the alternative frame structure, MS(s) need certain modifications to recognize and distinguish RS and BS.

Requirements and Recommendations

There are several requirements discussed here for the operation of the proposed frame structure. Initially, the MR-BS needs to be aware and distinguish RS(s) and MS(s). Also, the MR-BS needs to obtain all CQICH to determine the user access. Furthermore, RS should be able to produce its own preamble and also pass or produce FCH and MAP for its MS(s)

Legacy compatibility should be always considered for any MS(s) for its end-link (e.g., MS-RS, MS-BS). In addition, the frame structure should support different lengths and structure in each individual part. Therefore, different modulation & coding schemes could be applied depending on different link quality and channel conditions.

For a practical application, relay link could have minimum one sub-channel to full sub-channels, this should be supported by the frame structure. We suggest requiring that the BS should release relay link sub-channel(s) just after the transmission between BS-RS. In addition, for multihop application, RS should release its relay link sub-channel(s) just after the transmission between RS-RS. This requirement is not a requirement on sharing, but a requirement to support possible resource reuse.

References

[1] IEEE Standard for Local and metropolitan area networks, “Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems, Amendment 2: Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands”, IEEE, 28 February 2006.

[2] IEEE 802.16j-06/016r1, “Proposed Technical Requirement Guideline for IEEE 802.16 Relay TG”, IEEE 802.16j TG, 11th October 2006.

[3] WiMAX Forum, “Mobile WiMAX – Part I: A technical Overview and Performance Evaluation”, WiMAX, Forum, June 2006.

[4] WiMAX Forum, “Mobile WiMAX – Part II: A Comparative Analysis”, WiMAX, Forum, May 2006.

Dynamic Frame Structure for IEEE802.16j Relaying Transmission to Support Efficient Scheduling

IEEE 802.16 Presentation Submission Template (Rev. 8.3)

Document Number:

C80216j-06_224

Date Submitted:

2006-11-07

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Venue:

IEEE 802.16 Session #46, Dallas, Texas, USA

Base Document:

This is a response to a Call for Technical Proposal regarding IEEE Project P802.16j issued on 24th October 2006

http://ieee802.org/16/relay/docs/80216j-06_027.pdf

Purpose:

A partial technical proposal submitted IEEE 802.16j TG for considerations and further discussion.

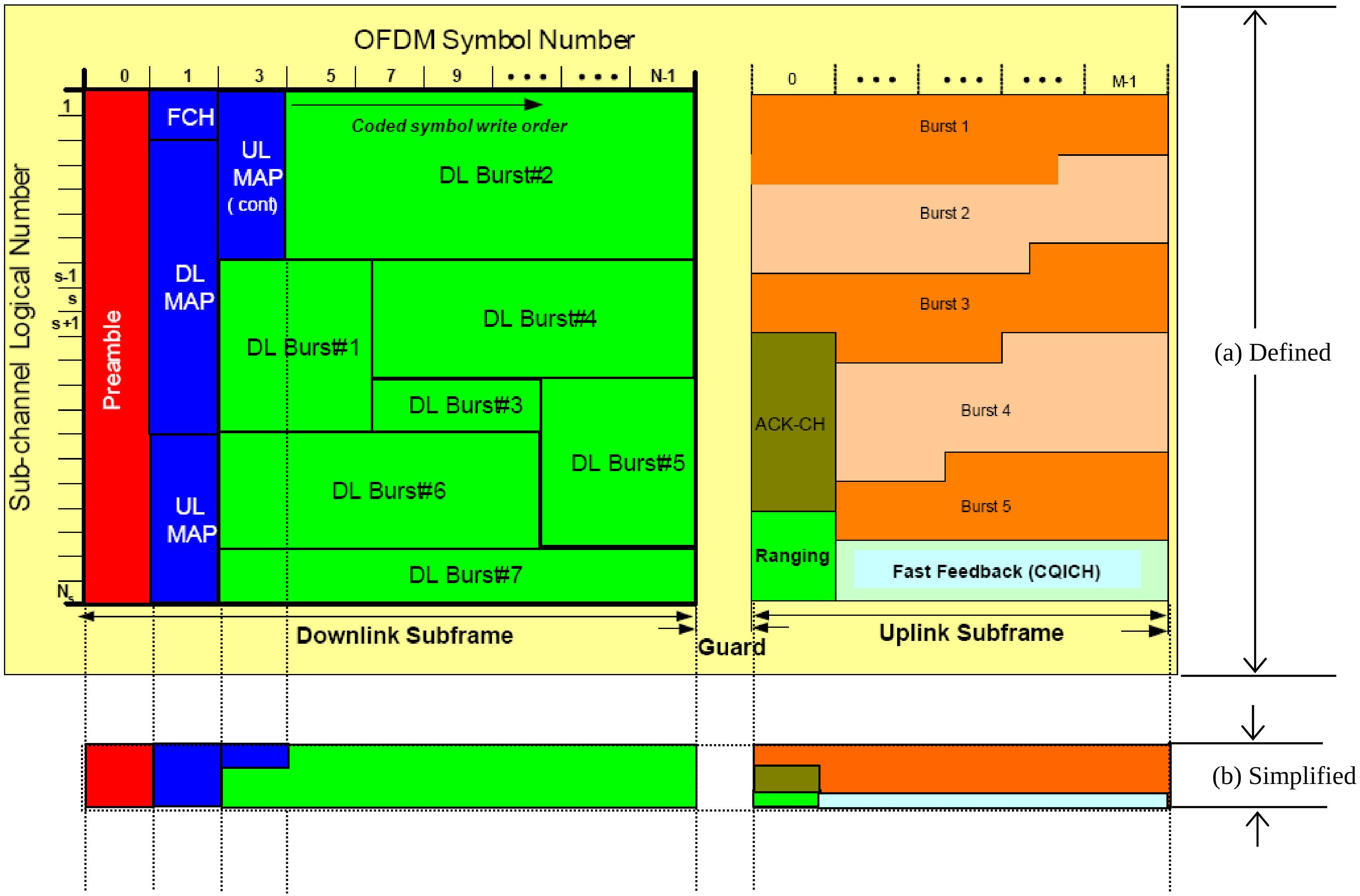
802.16 MAC scheduling service

- The MAC scheduler must efficiently allocate available resources in response to data traffic and time-varying channel conditions.
  - The data packets are associated to service flows with well defined QoS parameters in the MAC layer.
- The scheduling service is provided for both DL and UL traffic and the MAC supports frequency-time resource allocation in both DL and UL on a per-frame basis.
- MAC frame structure need to be pre-defined for efficient scheduling
- Frequency selective scheduling is also supported and specified by allocating a subset of sub-carriers to each MS for which the MS enjoys the strongest path gains

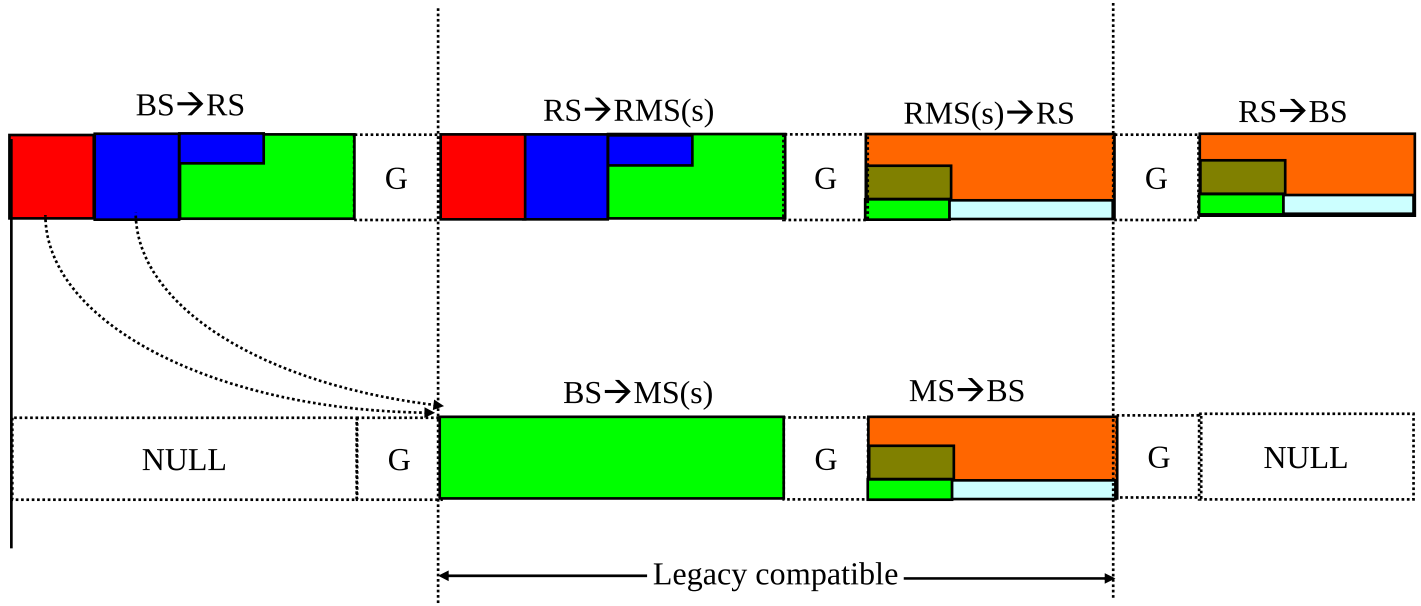
TDD and FDD situations

- The 802.16e PHY supports TDD and Full and Half-Duplex FDD operation;
- However, the initial release of Mobile WiMAX certifications profiles will only include TDD;
- For 16j, we propose to consider both TDD and FDD even though this document is mainly on TDD

WiMAX OFDMA frame structure



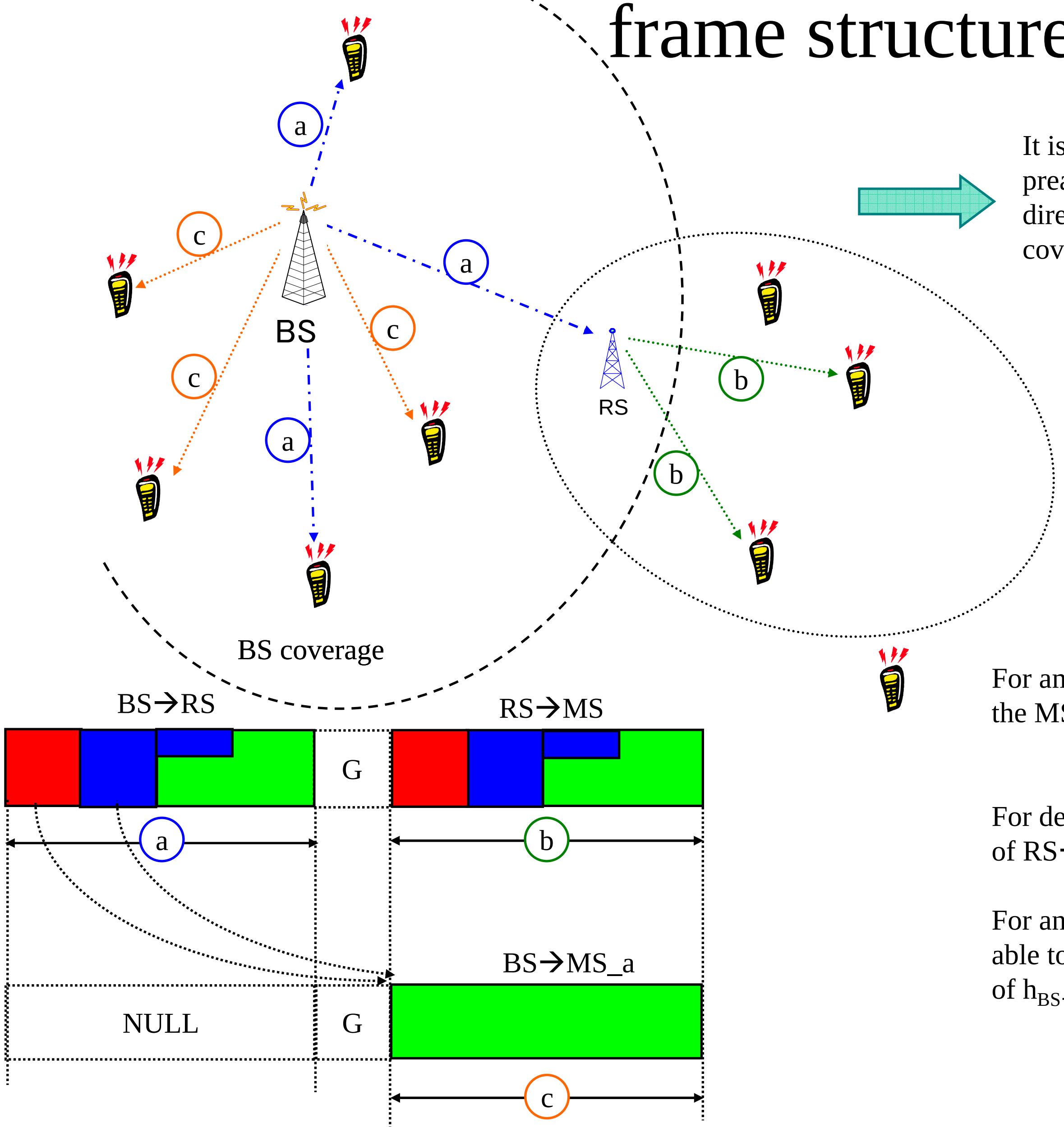
Frame structure for relaying application



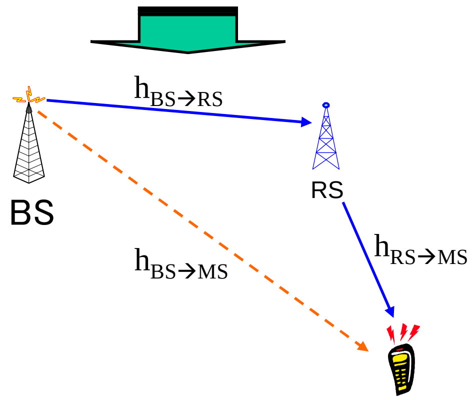
To any MSs, no difference between 16e and 16j

[Note]: MS can be referred to any MS(s) which is within BS coverage but out of RS coverage.
RMS represents relayed MS which is communicated with a RS.
BS → RS only means that the transmission from the BS includes a transmission to RS. In this expression that the BS also has transmission to its MS(s) (see the latter illustration)

Illustration of the DL application of the proposed frame structure



It is shown that for RS → BS, it has to have its own preamble, even though if in a case that the BS can directly communicate with the MS(s) in the RS coverage.



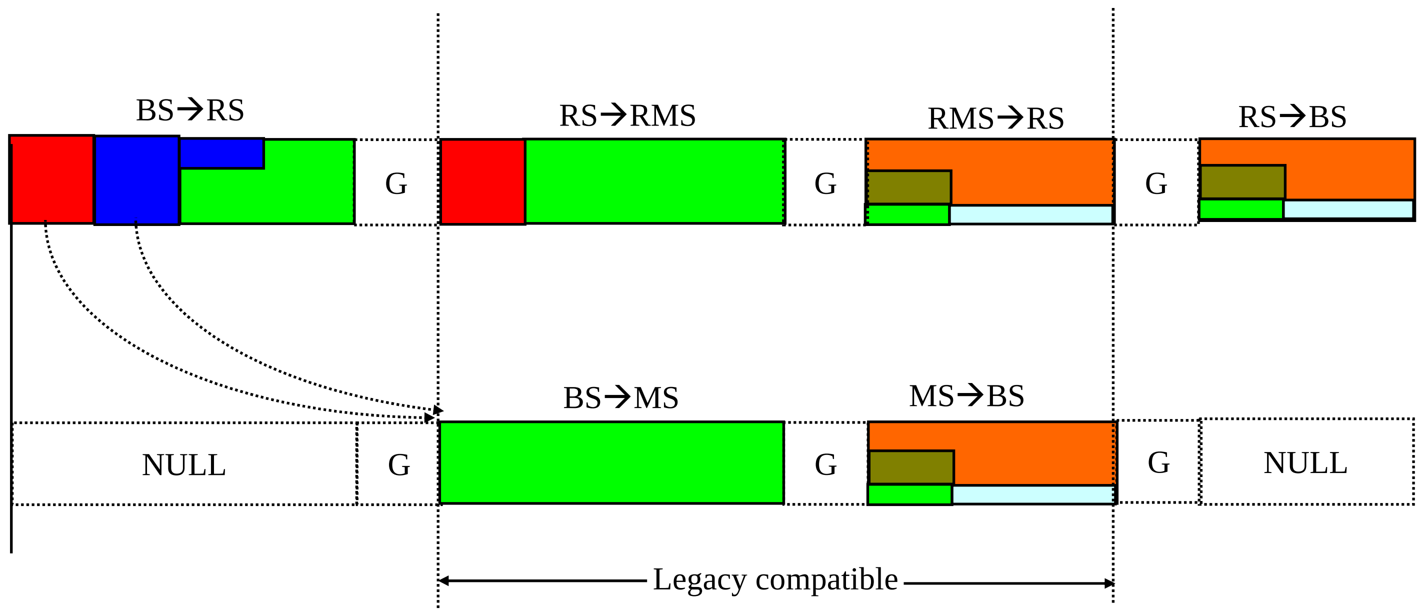
For amplified-forward RS, the channel be estimated at the MS is:

$$h = h_{BS \rightarrow RS} h_{RS \rightarrow MS}$$

For decoded-forward RS, the channel is only the part of RS→MS, $h_{RS \rightarrow MS}$

For any broadcast transmission from the BS, the MS is able to received by decoded by the estimated channel of $h_{BS \rightarrow MS}$

Alternative frame structure for the scenario that the BS can directly communicate with relayed MS(s)



In this case, it can assume that the relayed MS(s) received FCH and MAPs directly from the BS

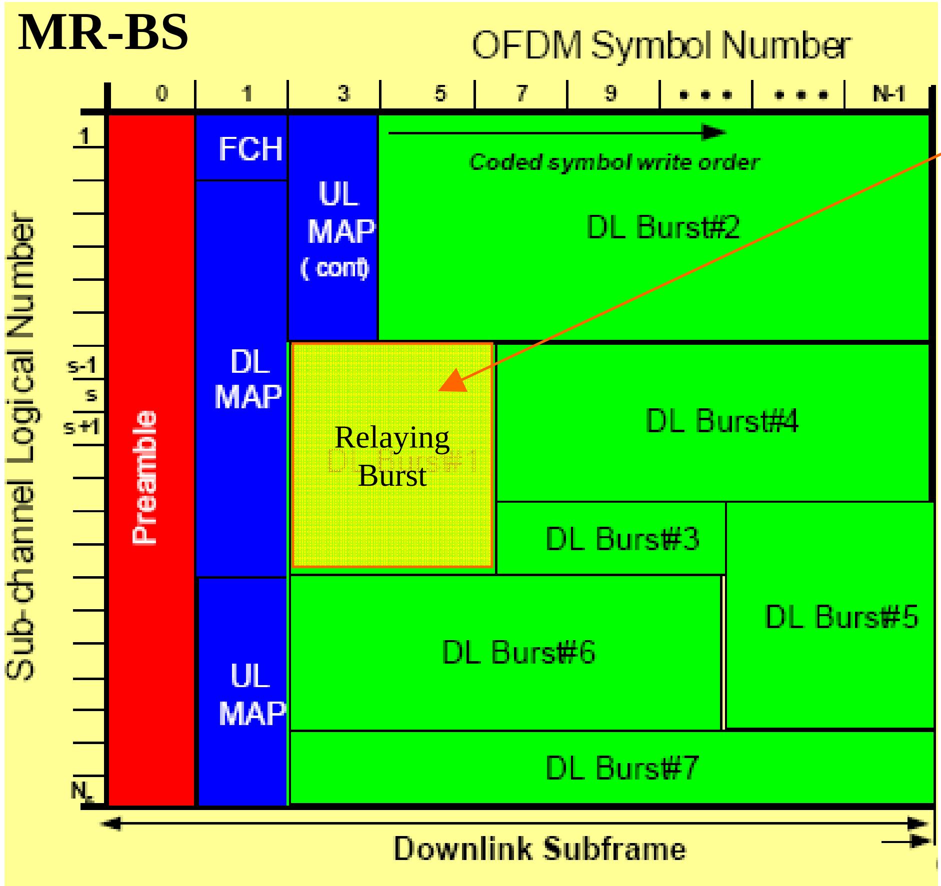
Requirements for the frame structure operation

- MR-BS need to be aware and distinct RS(s) and MS(s)
- MR-BS need to obtain all CQICH to determine the user access
- RS should be able to produce its own preamble and also pass or produce FCH and MAP for its MS(s)
- Legacy should be always compatible for any MS(s) for its end-link (e.g., MS-RS, MS-BS)
- The frame structure should support different length and structure in each individual parts
  - In addition, different AMC could be applied upon to different link quality and channel condition

Realistic considerations

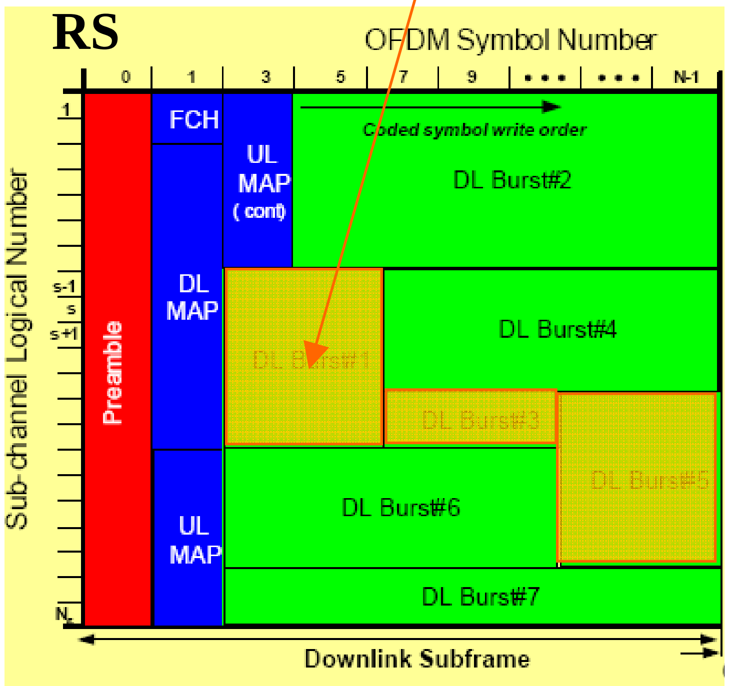
- Relay link could have minimum one sub-channel to several sub-channels
- BS should release relay link sub-channel(s) just after the transmission between BS-RS
- Preamble is required for RS-MS(s)
- However, for BS to support two groups MSs, preamble can be combined to one for quasi-static channel

One simple relay application with the proposed frame structure (DL case)



With defining relaying burst, MR-BS could treat RS as a normal MS (with aware of RS)

Accordingly, for coded-forward RS, it should be allowed to assign any suitable burst slot(s) (Depending on number of users and their triffic)



Further comments on the frames structure

- For self-interference-free relaying, the sub-channels for the link of RS→MS(s) should be the same as that of BS→RS
- Further for the self-interference-free relaying, no sharing would be allowed, however we suggest the 16j should have the optional feature to support the sharing
- In case the sharing scheme is operated, a further channel randomisation can be considered
- For the sharing perspective, scheduling has to be applied to avoid maximally interference
- Further for UL, adaptive array could be also applied on BS and RS to eliminate the interference