Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Frame Structures for Multihop Relay System**
Date Submitted	**2006-11-07**
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Re:	Call for Technical Proposals regarding IEEE Project P802.16j; See 802.16j-06/027
Abstract	This contribution identifies recommended changes to support Relay mode.
Purpose	This document provides a Technical Proposal for airlink frame structures for consideration by the 802.16j Multi-hop Relay Task Group
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Frame Structures for MultiHop Relay System

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Abstract

This contribution identifies a set of recommended airlink frame structures changes to support Relay mode.

Introduction

The 802.16 Relay mode, because of the introduction of a new network element – the Relay Station (RS) – must support additional types of airlink connections beyond those defined in the baseline 802.16-2005 standard for BS-MS links. These include:

- BS – MS and MS – BS,
- BS – RS and RS – BS,
- RS – MS and MS – RS, and
- RS – RS, both uplink and downlink, for the case of N>2 multihop relay

The 802.16j Relay standard needs to flexibly support a variety of airlink frame configurations in order to enable a variety of network deployment approaches, driven by differing operator deployment constraints (i.e. spectrum availability, siting), service offerings, network planning approaches and business goals.

This contribution provides a high level overview of the airlink frame structure alternatives that should be supported by the standard in order that have sufficient flexibility to be deployable in wide variety of situations. It does not propose specific details of new or modified preamble, MAP or information element definitions.

Deployment Scenarios

The cases outlined below define a minimum set of the standard in order that it be able to address a wide variety of service provider requirements. All cases assume centralized control of resource allocation at the MMR-BS. As a result, the MMR-BS transmits a preamble in the DL subframe of every frame.

In this contribution, the following definitions, as provided in 802.16j-06/014r1, apply:

- Access Link – An 802.16 radio link that originates or terminates at an MS. The access link is either an uplink or downlink as defined in IEEE 802.16-2004.
- Relay Link – An 802.16j radio link between an MMR-BS and an RS or between a pair of RSs. This can be a relay uplink or downlink

Case 1 – Separate Channels for Access and Relay Links

This scenario uses different channels for Access and Relay links. The frame structure is illustrated below:

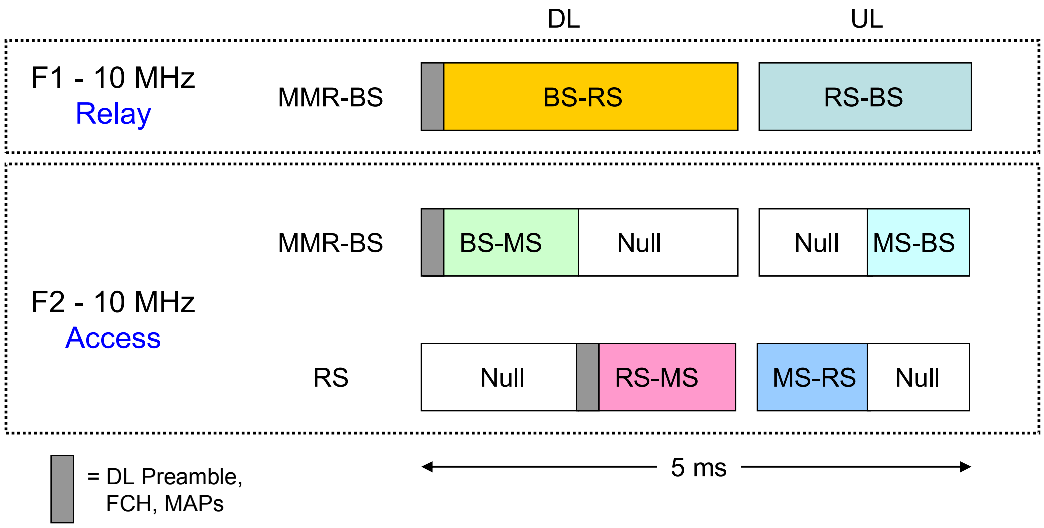

Figure 1. Separate Channel Frame Structure

Each separately-colored box identifies a frame or zone allocated to a specific type of link within a standard 802.16 OFDMA airlink frame. The zone boundaries are defined along symbol boundaries in the time domain in order to enable transmission in non-overlapping time periods by different network elements (e.g. MMR-BS, RS) within the same subframe period. Null zones are identified in regions where a particular type of network element does not transmit or receive in deference to another type of network element.

System operation is shown pictorially below:

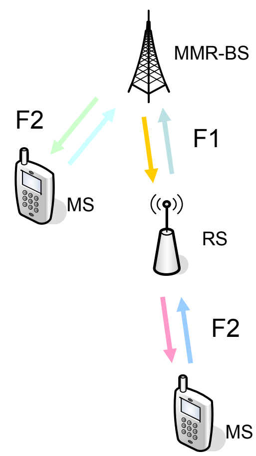

Figure 2. Separate Channel Operation

The characteristics of this configuration are:

- Different channels (denoted F1 and F2) are used for Relay (BS-RS and RS-RS) links and Access (BS-MS and RS-MS) links
- At least two distinct RF channels are required
- Separate radios in the RS are required for the RS to communicate on both access and relay links at the same time
- The solution provides dedicated high capacity for relay links, including support of enhanced physical layer techniques such as smart antennas at the MMR-BS
- The solution provides higher peak link rates and lower latency than schemes involving airlink frames alternating in time
- The solution enables training on both Relay and Access links to be continuously updated within a 5 ms timeframe
- Uplink training information received on both Relay and Access links is very recent (<5 ms) when utilized for the next downlink transmission:
  - MS-BS training information will be fresher than MS-RS information[1]
- A small number of RS-RS (Relay) links can be supported in the Access frame through a further segmentation or assignment of bandwidth to an RS-RS zone (not shown above)

This approach is best utilized when a service provider wishes to deploy an MMR-BS that provides very high capacity and is able to support a very large cell radius with a high density of directly-connected Relay Stations and a small number of RS-RS links. It is dependent on the availability of sufficient spectrum to enable at least one channel to be dedicated to Relay links.

[1] This has been chosen in order to enable the training of larger antenna arrays at the BS than at the RS.

Case 2 – Single Channel, Alternating Frames

This scenario uses alternating frames for Relay and Access links. The frame structure is illustrated below. The transmit and receive periods for downstream network elements are not shown:

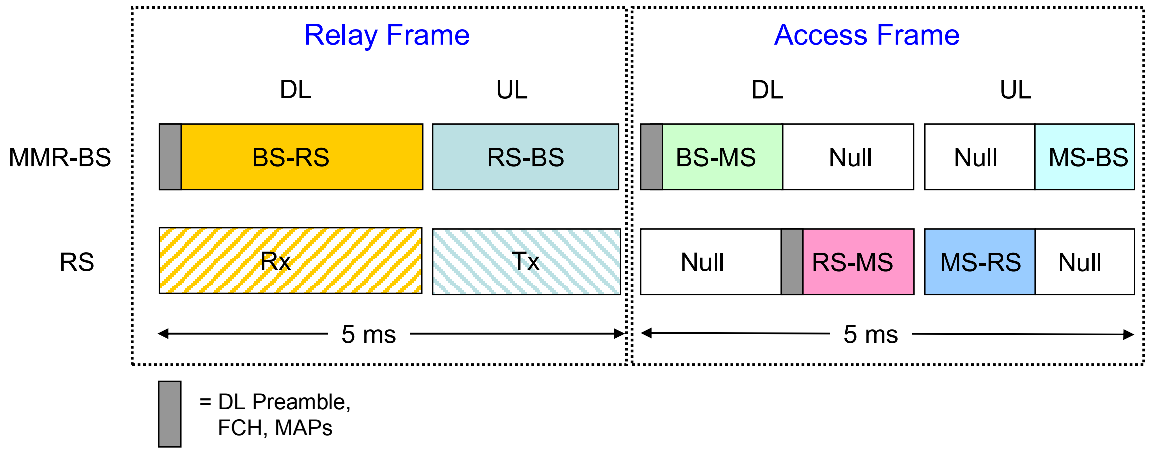

Figure 3. Single Channel, Alternating Frame Structure

Each separately-colored box identifies a frame or zone allocated to a specific type of link within a segmented 802.16 OFDMA airlink frame. The zone boundaries are defined along symbol boundaries in the time domain in order to enable transmission in non-overlapping time periods by different network elements (e.g. MMR-BS, RS) within the same subframe period. Null zones are identified in regions where a particular type of network element does not transmit or receive in deference to another type of network element.

System operation is shown pictorially below:

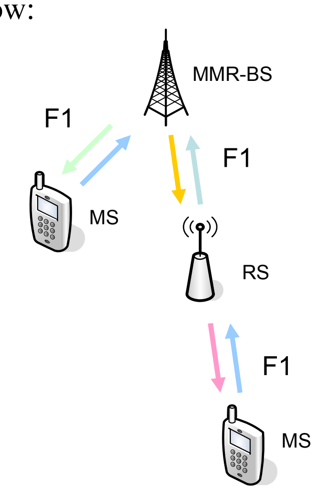

Figure 4. Single Channel, Alternating Frame Operation

The characteristics of this case are:

- A single RF channel (denoted F1) is used for Relay (BS-RS and RS-RS) links and access (BS-MS and RS-MS) links
- Alternating timeslots are dedicated to Relay and Access links
- The solution supports lower cost Relay stations incorporating a single radio used for both access and relay links
- The solution provides dedicated capacity (every other frame) for Relay links
- The solution will provide lower peak link rates and higher latency than schemes involving two channels
- Uplink training information received on both Relay and Access links is at least 5 ms old when utilized for the next downlink transmission resulting in less robust uplink training performance
    - MS-BS training information will be fresher than MS-RS information
    - RF performance will not be as good as the two channel case (case 1) because of the latency associated training information
- A small number of RS-RS (Relay) links can be supported in the Access frame through a further segmentation or assignment of bandwidth

This approach should be used when a service provider wishes to deploy an MMR-BS with moderate capacity and cell radius, supporting a relatively high number of low cost Relay Stations. It is suitable for situations in which the operator has a small amount of spectrum available and is tolerant to higher latency.

Case 3 – Single Channel, Combined Frame with Access and Relay Zones

The frame structure is shown below. The transmit and receive periods for downstream network elements are not shown:

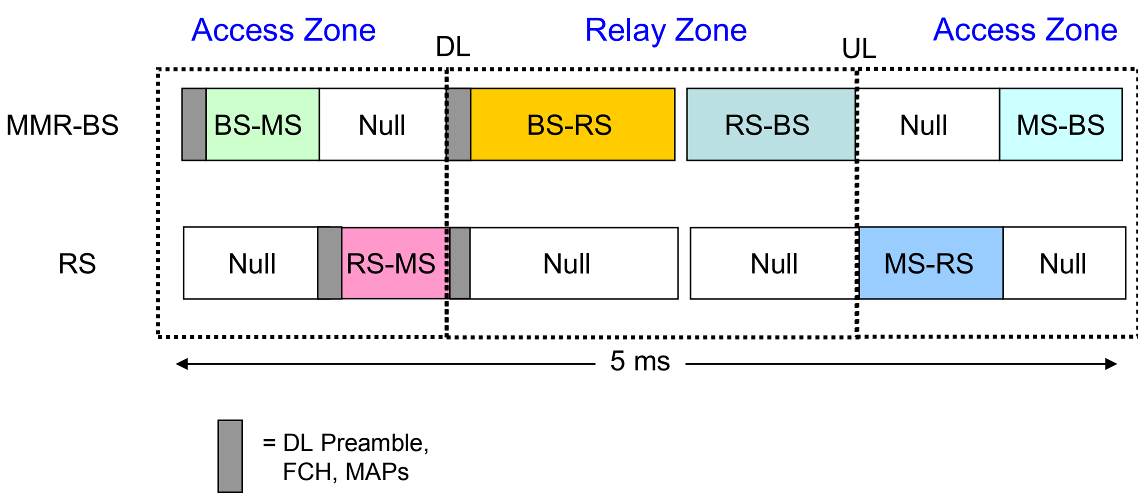

Figure 5. Single Channel, Combined Frame

System operation is shown pictorially below:

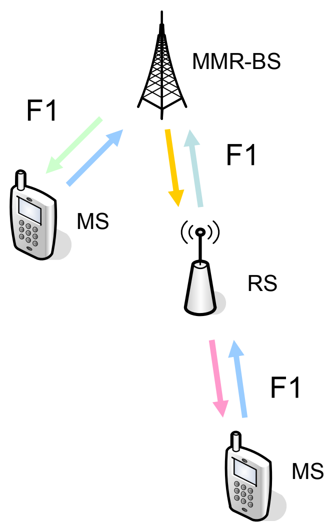

Figure 6. Single Channel, Combined Frame Operation

The characteristics of this case are:

- A single RF channel (denoted F1) is used for Relay (BS-RS) links and access (BS-MS and RS-MS) links
- All timeslots support both Relay and Access links
- The solution supports lower cost Relay stations incorporating a single radio used for both access and relay links
- The solution does not provides dedicated capacity for relay links, as the available bandwidth is allocated dynamically within each frame between Access and Relay
- The solution will provide lower peak link rates than schemes involving two channels
- The solution will provide lower latency rates than schemes involving alternating timeslots
- Uplink training information received on both Relay and Access links is less than 5 ms old when utilized for the next downlink transmission resulting in reasonable uplink training performance
    - MS-BS training information will be fresher than MS-RS information
    - MS-RS training information will be fresher than RS-BS information
    - RF performance will not be as good as the two channel case (case 1) because of the latency associated with training information
- RS-RS (Relay) links can be supported in the Access frame through a further segmentation or assignment of bandwidth

This approach should be used when a service provider wishes to deploy an MMR-BS with relatively low capacity and cell radius, supporting a relatively small number of low cost Relay Stations. It is suitable for situations in which the operator has a small amount of spectrum available and is tolerant to higher latency.

Case 4 – Hybrid, Combined Frame with Alternating Relay

This case is intended to support a relatively large amount of multihop (RS-RS) relaying at the expense of additional MMR-BS – RS latency. The frame structure is shown below. The transmit and receive periods for downstream network elements are not shown:

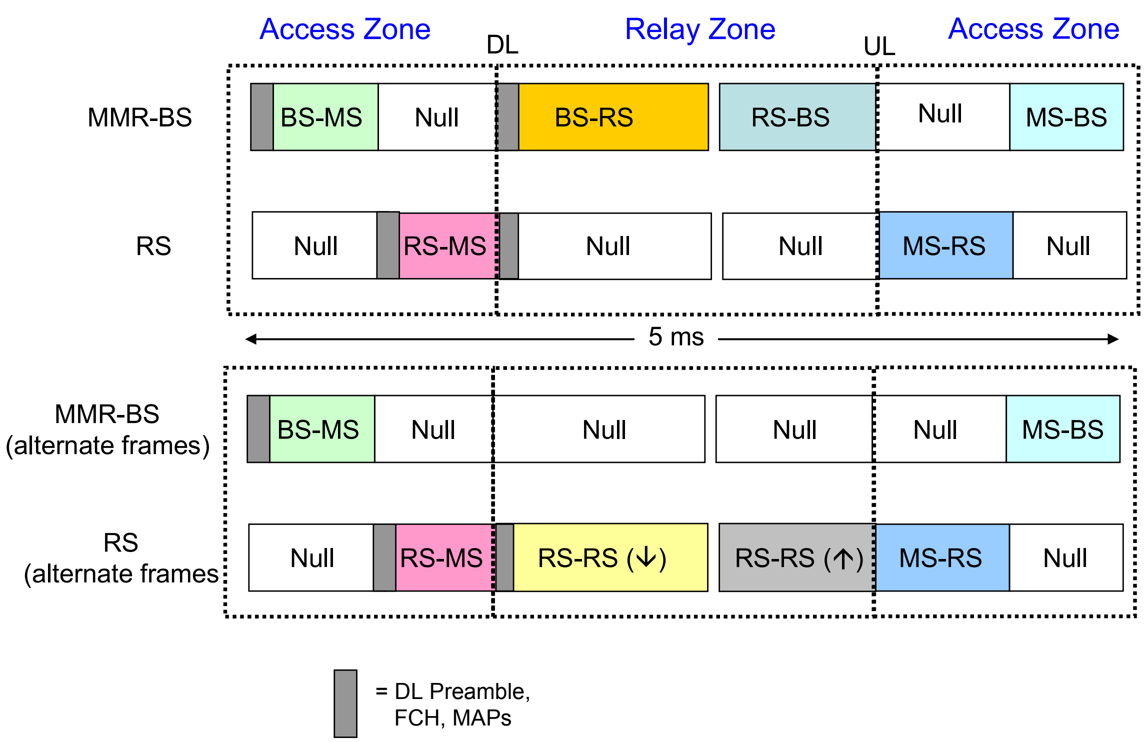

Figure 7. Combined Frame with Alternating Relay Zone

System operation is shown pictorially below:

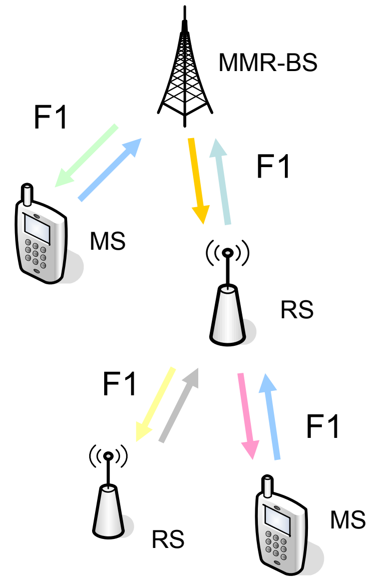

Figure 8. Hybrid Combined, Alternating Relay Operation

The characteristics of this case are:

- A single RF channel (denoted F1) is used for Relay (BS-RS and RS-RS) links and access (BS-MS and RS-MS) links
- All timeslots support both Relay and Access links, however the frames alternate between different types of Relay links (BS-RS or RS-RS) under scheduler control
- The solution supports a high percentage of RS-RS links through the assignment of alternate frames to either BS-RS or RS-RS links at the expense of higher latency on the MMR-BS – RS link
- The solution supports lower cost Relay stations incorporating a single radio used for both access and relay links
- The solution does not provide dedicated capacity for Relay links, as the available bandwidth is allocated dynamically within each frame to Access and Relay
- The solution will provide lower peak link rates than schemes involving two channels
- Uplink training information received on both Relay and Access links is at least 5 ms old when utilized for the next downlink transmission resulting in poorer uplink training performance
  - MS-BS training information will be fresher than MS-RS information
  - RF performance will not be as good as the two channel case because of the latency associated with training information

This approach should be used when a service provider wishes to deploy an MMR-BS supporting a relatively high number of RS-RS links. It is suitable for situations in which the operator has a small amount of spectrum available and can tolerate higher traffic latency.

Summary

The following table summarizes the characteristics of each case:

	Case 1 Separate Channels	Case 2 Alternating Frames	Case 3 Combined Frames	Case 4 Hybrid, Alternating Relay
Minimum Number of RF Channels	2	1	1	1
Number of Radios in RS	2	1	1	1
MMR-BS Capacity	High	Medium	Medium	Low
Dedicated Relay Capacity	Yes	Yes	No	No
RS Density	High	High	Low	Medium
Peak Link Rates	Higher	Lower	Lower	Lower
Traffic Latency	Low	High	High	High
MS-BS Training Latency	<<5ms	<10ms	<<5ms	<10ms
MS-RS Training Latency	<5ms	<10ms	<5ms	<10ms
RS-BS Training Latency	<<5ms	<10ms	<5ms	<10ms
Amount of RS-RS relaying	Low	Low	Low	High

It can be seen that no solution is optimal and that all have their benefits and drawbacks. This illustrates the point that flexibility in defining the airlink frame structure when deploying an MMR network is very important.

Proposal

Insert the following text in 8.4.4.8:

The 802.16 MMR Relay mode utilizes the OFDMA frame structures and zones defined in 8.4.4.2 with additional features provided to support the operation of Relay stations.

Separate zones within an airlink frame are assigned to the different types of links required in an MMR Relay system:

- BS – RS: Relay – Type 1
- RS – BS: Relay – Type 1
- RS – RS: Relay – Type 2
- RS – MS/SS: Access – Type 1
- MS/SS – RS: Access – Type 1
- BS – MS/SS: Access – Type 2
- MS/SS – BS: Access – Type 2

The following types of airlink frame structures are supported:

- Dedicated channels for Access and Relay links
- Alternating frames dedicated to Access or Relay links
- Combined frames supporting both Access and Relay links
- Combined frames supporting both Access and Relay links with alternating assignment of bandwidth to different types of Access and Relay

A “null zone”, in which a base station or relay station does not transmit or receive, is utilized in order to support the airlink frame structures associated with Relay mode. The purpose of the null zone is to permit a network element in a Relay network to suppress transmissions within a particular zone in favor of a different element, for example, when BS and RS transmissions use non-overlapping zones within the same airlink frame.