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Re:	IEEE 802.16j-06/027: “Call for Technical Proposals regarding IEEE Project P802.16j”	
Abstract	This document is to provide an analytic framework for designing relaying frame structure	
Purpose	Only for discussion	
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Relay Station Modes - design objectives of relaying frame structure

Introduction

This document is to provide an analytic framework for designing relaying frame structure

Description of RS Modes

As defined in IEEE 80216j/014r1, there are two kinds of Multihop Relays in a Multihop Relay system based on the frequency allocation. One is in-band (IB) Relay Station (RS) where the Multihop Relay system uses the same RF channels on relay (i.e. MR-BS-to-RS or RS-to-RS) and access links (i.e. MR-BS-to-MS or RS-to-MS). The other one is out-of-band (OB) RSs where the Multihop Relay system uses different RF channels on relay (i.e. MR-BS-to-RS or RS-to-RS) and access links (i.e. MR-BS-to-MS or RS-to-MS). In order to provide coverage extension and/or throughout enhancement in a Multihop Relay system under limited radio resources, the deployment of the MR-BS and RS should be flexible enough to accommodate several modes of RSs co-existing in a Multihop Relay system. Moreover, an RS could adaptively change its mode depending on the operation environment especially in mobility.

There are six modes of RSs applicable to practical MR deployment, namely OB, IB-NP, IB-AP, IB-SP-D, IB-SP-S-I, and IB-SP-S-D. They are categorized by the frequency allocation, frame-start DL preamble, segment ID, and cell ID as shown in Figure 1. Because segment ID and cell ID have to be derived by an MS or an RS from the frame-start DL preamble it received, each RS mode is mainly characterized based on the frequency and frame-start DL preamble.

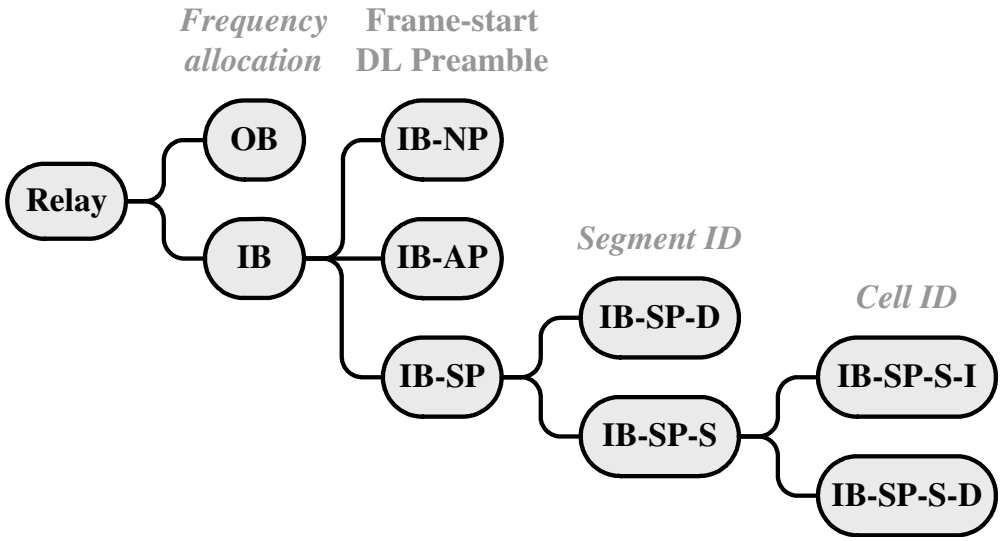


Figure 1: Categories of Multihop Relays

- OB: an OB RS operating at different frequency from the serving MR-BS shall transmit a frame-start DL preamble and FCH independently of the MR-BS.
- IB-NP: an IB-NP RS does not transmit any frame-start DL preamble and FCH. It could be used when all MSs in the IB-NP RS cell can successfully decode the frame-start DL preamble and FCH sent by the serving MR-BS. One possible usage scenario of IB-NP RS is to relay the upstream traffic from MS to MR-BS only.

- IB-AP: an IB-AP RS transmits a frame-start DL preamble and FCH at separated OFDMA symbols from those used by the serving MR-BS. The frame-start DL preamble sent by IB-AP RS and the serving MR-BS could be the same or different. IB-AP RS introduces extra overheads such as preamble, FCH, etc., in each hopping level and, hence, it requires a larger frame duration to accommodate the overheads, which limits the MS and RS mobility.
- IB-SP-D: an IB-SP-D RS transmits a frame-start DL preamble and FCH on OFDMA symbols that are the same as those used by the MR-BS. The frame-start DL preamble sent by IB-SP-D RS is different from the one sent by the serving MR-BS, plus the two preambles are with different segment IDs.
- IB-SP-S-I: an IB-SP-S-I RS transmits a frame-start DL preamble and FCH using the same OFDMA symbols as the serving MR-BS. The frame-start DL preamble sent by IB-SP-S-I RS is identical to the one sent by the serving MR-BS. In case that an MS or a child RS receives signals from the serving MR-BS and IB-SP-S-I RS simultaneously, the two frame-start DL preambles and FCHs are treated as multipath signals by the MS or the child RS.
- IB-SP-S-D: an IB-SP-S-D RS transmits a frame start DL preamble and FCH using the same OFDMA symbols as the serving MR-BS. The frame-start DL preamble sent by IB-SP-S-D RS is different from the one sent by the serving MR-BS but the two preambles are with same segment ID. In case that an MS receives the frame-start DL preambles and FCHs from the serving MR-BS and IB-SP-S-D RS simultaneously, it must be mitigated as co-channel interference.

The comparisons among different modes of RSs in terms of frame-start DL preamble, segment ID, and Cell ID are illustrated in Table 1. Furthermore, an example illustrating a possible deployment scenario of using different modes of RSs is shown in Figure 2.

Table 1: Comparisons between Multihop Relay Modes

Mode	Tx Frame-start DL Preamble (Tx Timing relative to MR-BS)	Same Segment ID as MR-BS	Same Cell ID as MR-BS	Notes
OB	Yes (Don't Care)	Possible	Possible	
IB-NP	No (N/A)	N/A	N/A	
IB-AP	Yes (Asynchronous)	Possible	Possible	
IB-SP-D	Yes (Synchronous)	No	No	
IB-SP-S-I	Yes (Synchronous)	Yes	Yes	Multipath signals from IB-SP-S-I RS and MR-BS at MS or child RS
IB-SP-S-D	Yes (Synchronous)	Yes	No	Co-channel interference from IB-SP-S-D RS and MR-BS at MS or child RS

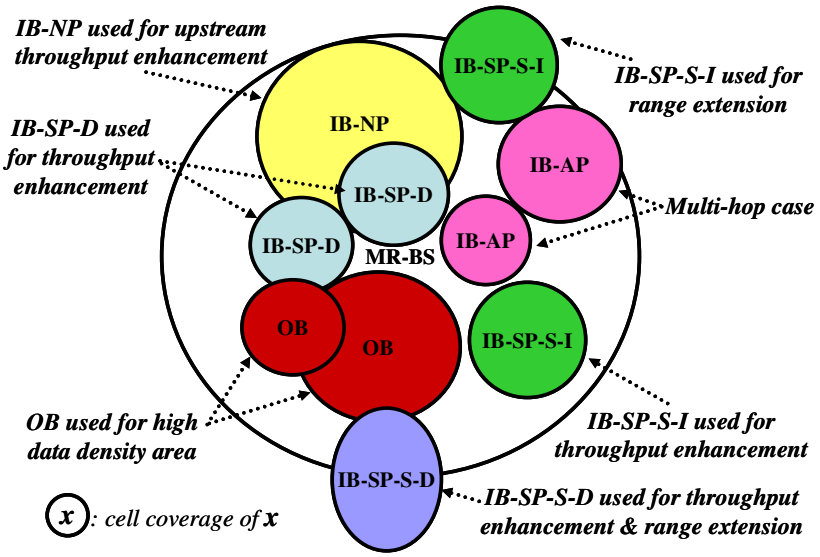
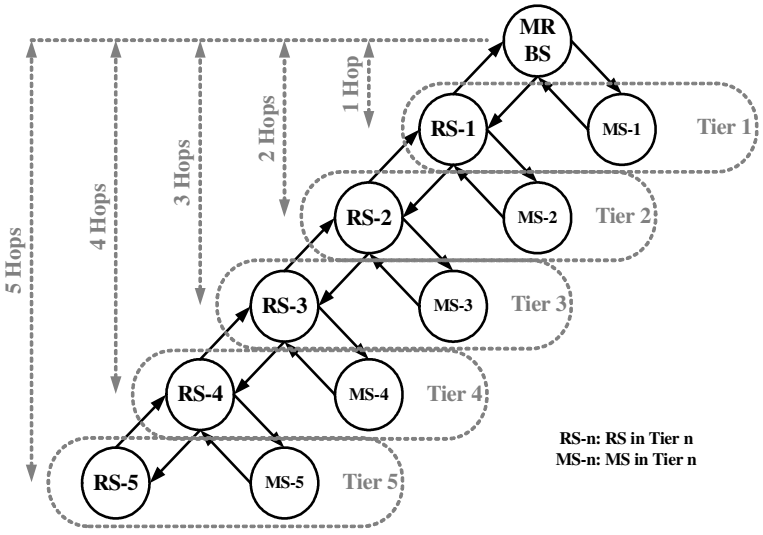
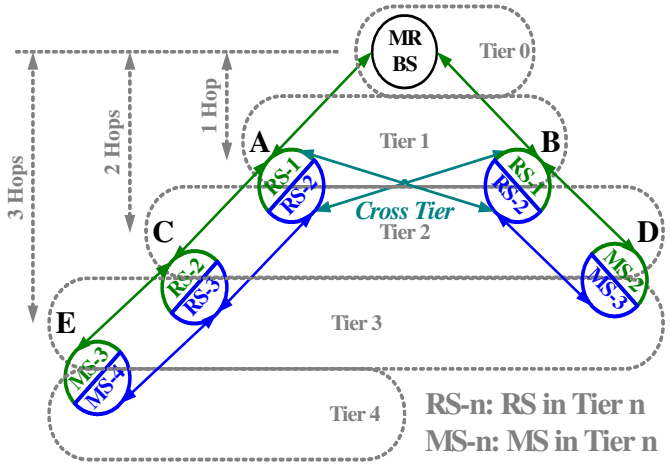


Figure 2: Deployment Example of Different Mode RSs

The OB RS requires no new frame structure, the 16e OFDMA frame structure defined in IEEE 802.16e-2005 could be used because the transmission of an OB RS is independent of the transmission of the serving MR-BS. The IB RS, however, requires a new relaying frame structure supporting multihop relaying due to the fact that the MR-BS, IB RS and MS are transmitting at the same frequency. Figure 3 depicts the typical topology of a Multihop Relay Network, where RSs and MSs in Tier n denoted as RS-n and MS-n, respectively. Although IEEE 802.16j-06/016r1 defines 2-hop relaying to be mandatory and more than 2-hop relaying to be optional in a Multihop Relay system, the relaying frame structure shall have the flexibility to support more than 2-hop relaying.



(a) Simple Scenario: each RS only in one tier



(b) Complex Scenario: one RS in more than one tiers

Figure 3: Tires in a Multihop Relay Network

By utilizing OFDMA channel segmentation, a deployment example for a Multihop Relay system is given in Figure 5, where 1 hop (Cells 3 & 4), 2-hop (Cells 0 & 5, where Cell 5 is a 3-sector MR-BS), and 3-hop (Cell 1 & 2) scenarios are depicted. By using the frame structure shown in Figure 4, the traffic exchange in MR-BS cells could be done as follows. The relay traffic is exchanged between MR-BS/RS and RS using either a specific segment or several segments in RS subframe, and then the access traffic within diamond and hexagonal areas is exchanged simultaneously by using a specific segment in the next frame.

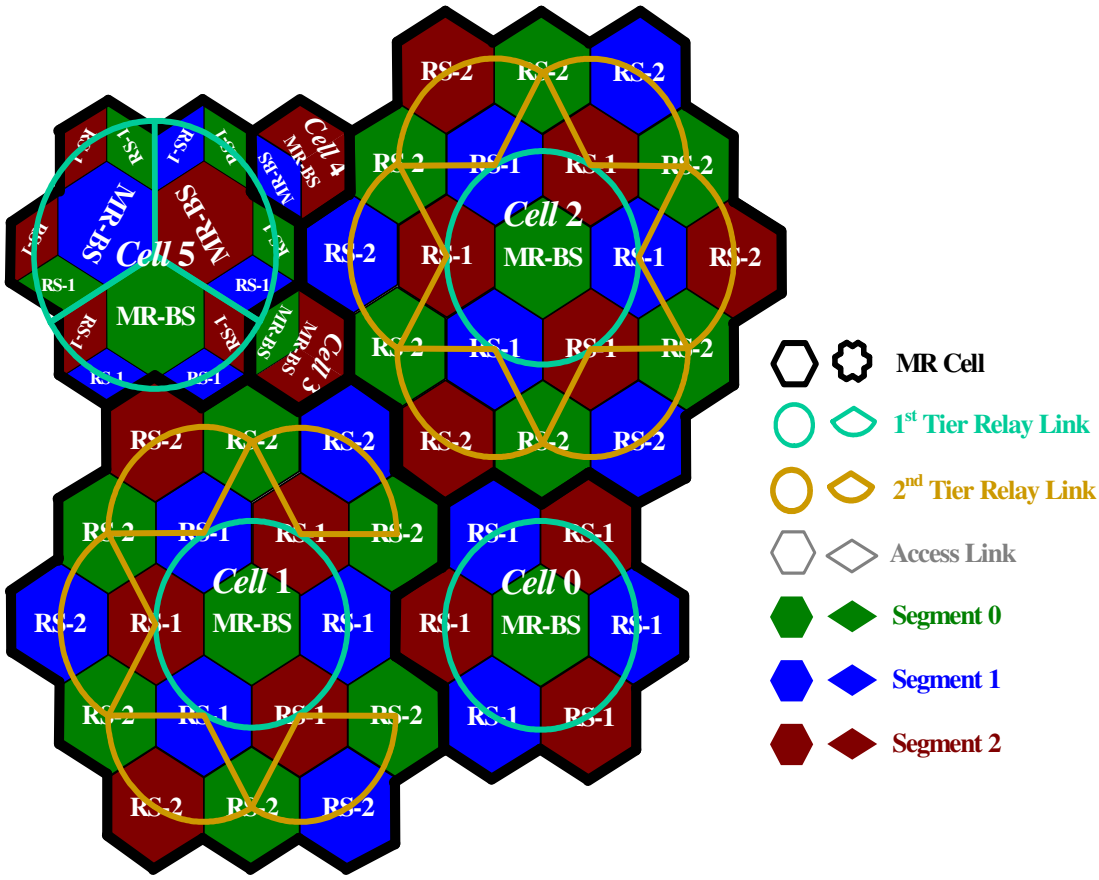


Figure 5: Example of deploying a Multihop Relay System

Design objectives of relaying frame structure

Based on the above descriptions, the relaying frame structure for a Multihop Relay system

1. shall meet the requirement of MS backward compatibility.
2. shall support RS of 2-hop.
3. should accommodate different modes of RS.
4. should support Mobile RS.
5. should be flexible to support RS of more than 2-hop.
6. should support scenarios of complex topology.
7. should minimize transmission overheads and relaying path delay based on implementation considerations.
8. should maximize concurrent transmissions among MR-BS, RS and MS.

Summary

1. Various modes of RSs could co-exist in a Multihop Relay system.
2. The relaying frame structure for a Multihop Relay system

a) shall meet the requirement of MS backward compatibility.

b) shall support RS of 2-hop.

c) should accommodate different modes of RS.

d) should support Mobile RS.

e) should be flexible to support RS of more than 2-hop.

f) should support scenarios of complex topology.

g) should minimize transmission overheads and relaying path delay based on implementation considerations.

h) should maximize concurrent transmissions among MR-BS, RS and MS.