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Title	**Frame Structure for Flexible Resource Allocation**
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Re:	This document is in response to call for technical proposals IEEE 80216-06/027 dated 15 October 2006.
Abstract	This document describes the frame structure for flexible resource allocation.
Purpose	This contribution is provided as input for the IEEE 802.16j baseline document.
Notice	
Release	
Patent Policy and Procedures	

Frame Structure for Flexible Resource Allocation

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1 Introduction

This contribution proposes a frame structure for 802.16 with MMR, which is backward compatible to the frame structure in the legacy 802.16e standard. As indicated in [1], it is necessary to maintain backward compatibility such that MS conforming to legacy 802.16e operation can fully function.

The proposed frame structure has the following advantages:

- It enables RS nodes to relay data between BS and MS for both uplink and downlink, regardless of the number of hops.
- The relaying of data from source to destination may be achieved in the same OFDMA frame.
- The frame structure enables the flexibility for BS and multiple RSs to transmit during the same OFDMA symbol.
- The frame structure enables the flexibility for BS and multiple RSs to transmit during the same burst, allowing cooperative relay, as well as allowing efficient frequency reuse (i.e. simultaneous transmission, as in [2]).
- The division of resources is done centrally at the BS by the scheduler, and does not require new signaling itself.

2 General Description

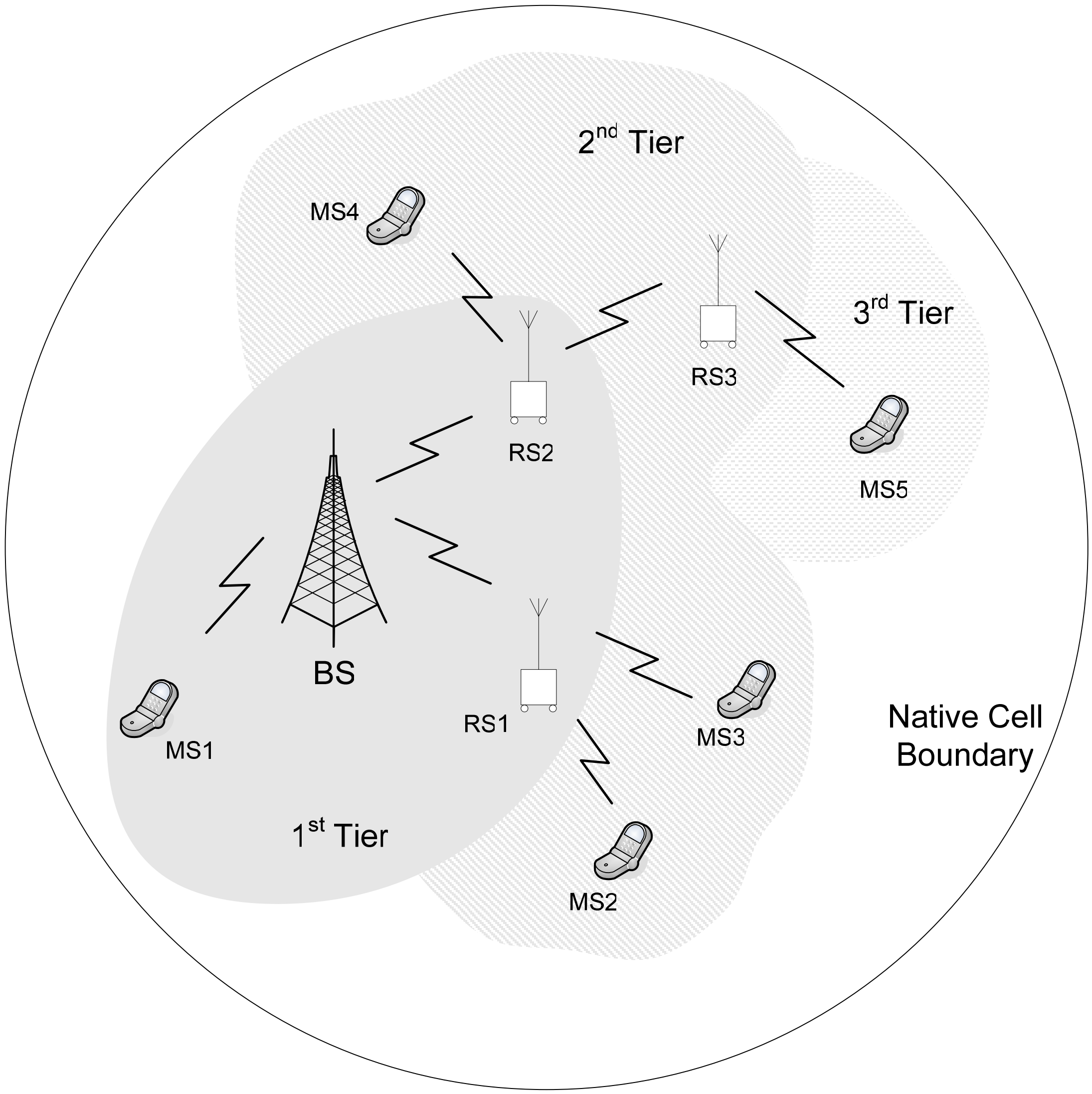

Figure 1 Typical Relay System where all relay and mobile stations can receive control information from the base station.

In this setup, we consider a relay setup where all relay stations (RS) and mobile stations (MS) receive control information such as preamble, FCH and MAP directly from the base station (BS). The RS may assist the BS in transmitting data; however, the MS is not aware of this operation. In other words, the MS is not aware of the presence of relays and continues to receive or transmit packets as if they are from or to the BS directly.

Although the transparent relay does not require the transmission of additional preamble or other broadcast information which are normally necessary for coverage extension, it is still possible to extend the cell coverage. In addition, the transparent relay does increase the link budget, and thus improve the reliability of uplink transmissions as well as increase the throughput of downlink communication. Therefore, the proposed frame structure supports both coverage extension and throughput enhancement.

3 Frame Structure for Transparent Relays

Figure 2 illustrates the proposed frame structure for systems supporting two hops. The shared transmission zone can be used for cooperative relaying, which will be explained in more details in Section 4.

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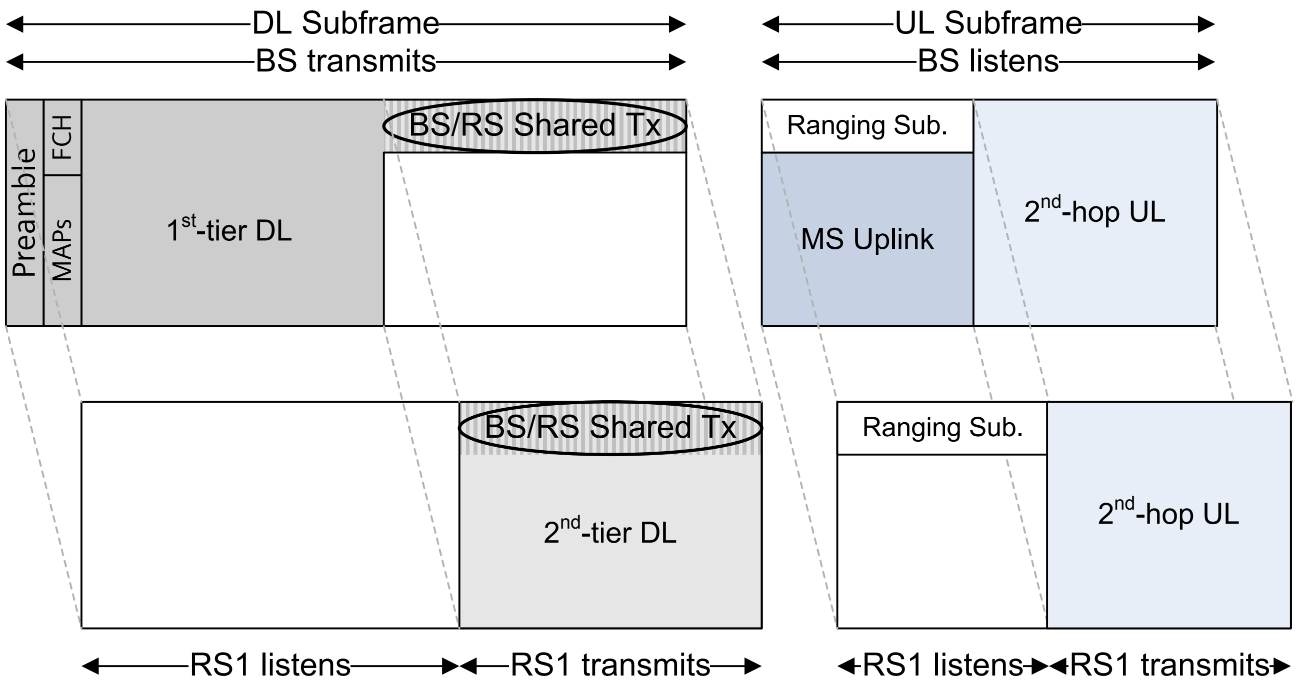

Figure 2 Frame Structure for Two-Hop Transparent Relay System

Here, the BS can transmit during the entire DL subframe. During the first part of the subframe, the resources are used solely for 1st-tier transmissions (i.e. BS-MS or BS-RS). During the second part of the downlink subframe, the resources can be used for both 1st-tier transmissions and 2nd-tier transmissions (RS-MS).

In the figure, the placements of the 2nd-tier DL region and the 1st-tier DL region overlap, which signifies that during this time period, the resources are shared between the two hops. This method allows the BS to be in use even after 2nd-tier transmissions are initiated. Cooperative relaying may be enabled in this shared region.

The assignment of resources is done by the BS on a frame-by-frame basis. By decoding the MAP information, each RS is assigned the CIDs for the transmissions it needs to listen. If the decoding is successful, the RS transmits relayed messages in the assigned allocation as instructed in the MAP.

Additional signaling is needed to indicate to the RS when to listen and when to relay in the downlink. DL-MAP message shall contain additional IE(s) instructing RSs which bursts are first-hop bursts and which bursts shall be used as second-hop bursts for data forwarding.

The scheduler is responsible for partitioning the resources (i.e. burst allocation) between these hops in the downlink. It is also responsible for taking into account the RS turnaround time required to switch between transmitting and receiving modes.

Unlike the DL subframe, the UL subframe is divided into two zones by time division. The first zone is dedicated for MS uplink transmissions, and includes the ranging subchannel. In the second zone (the second-hop zone), the RS forwards data to the BS. To provide backward compatibility to existing 802.16e devices, only the MS uplink region can be used for MS uplink transmission; the second-hop zone shall be inaccessible for MS's transmissions.

Additional signaling to the RS is needed to keep backward compatibility in the uplink subframe. In order to keep MS silent during this interval, specific IEs only for RSs shall be used in UL-MAP to specify second-hop bursts. The sizes of UL zones may vary in time to utilize bandwidth resources efficiently.

Ranging and bandwidth request mechanisms remain the same as in IEEE 802.16e-2005. Due to the small number of relays as compared to the number of mobile stations, periodic ranging of the RS can be done over dedicated uplink bursts.

We allow simultaneous transmission provided that the receiver nodes are sufficiently separated. This is also the task of the scheduler. For example, if the target nodes of RS1 and RS2 are separated and intra-cell transmission is minimal, then the frame structure for RS1 and RS2 can be as follows:

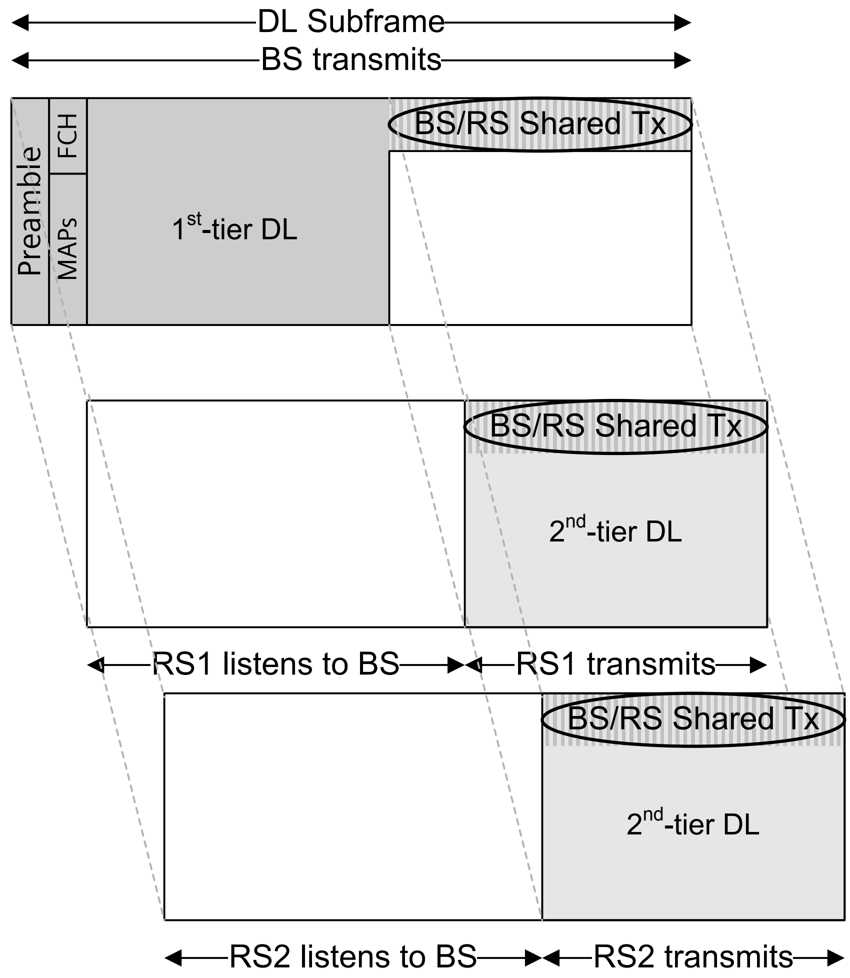

Figure 3 DL Subframe Structure for Simultaneous Transmission

That is, we do not prohibit RS1 and RS2 from transmitting in the same burst in the downlink.

4 Using the Proposed Frame Structure

The proposed frame structure allows a shared transmission region in the downlink, in which two or more stations can be transmitting simultaneously. This shared transmission region can be used for cooperative relay.

If the target CIDs are identical in the shared transmission region, then cooperative relay is achieved as shown in Figure 4:

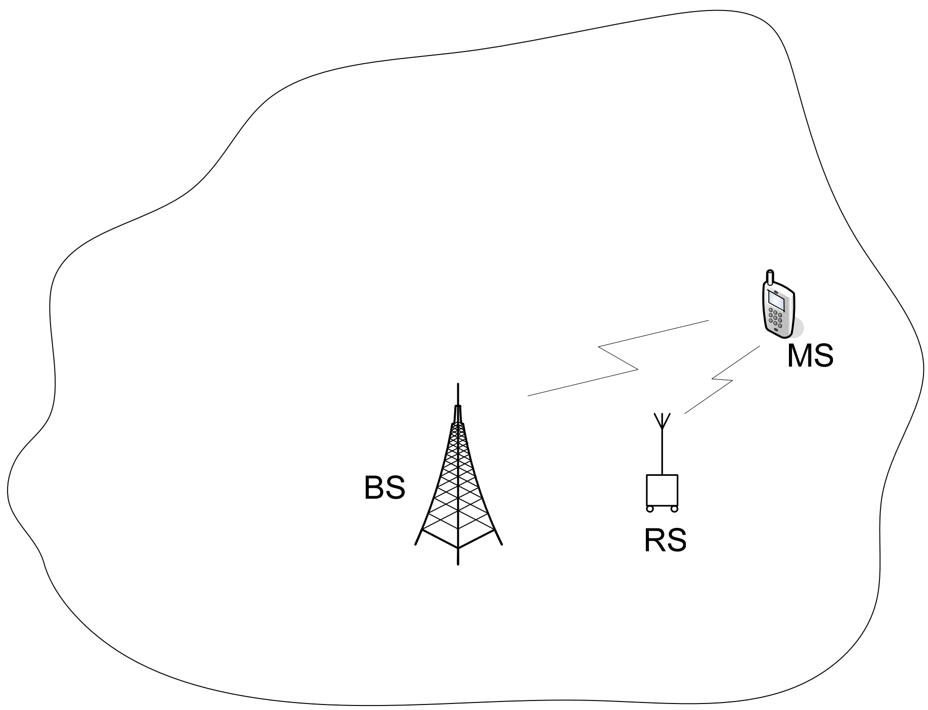

Figure 4 Cooperative Relay

If the target CIDs are not identical then simultaneous transmission as in [2] can be achieved as shown in Figure 5. In the cited contribution, simultaneous transmission refers to using spatial separation to enable resource reuse:

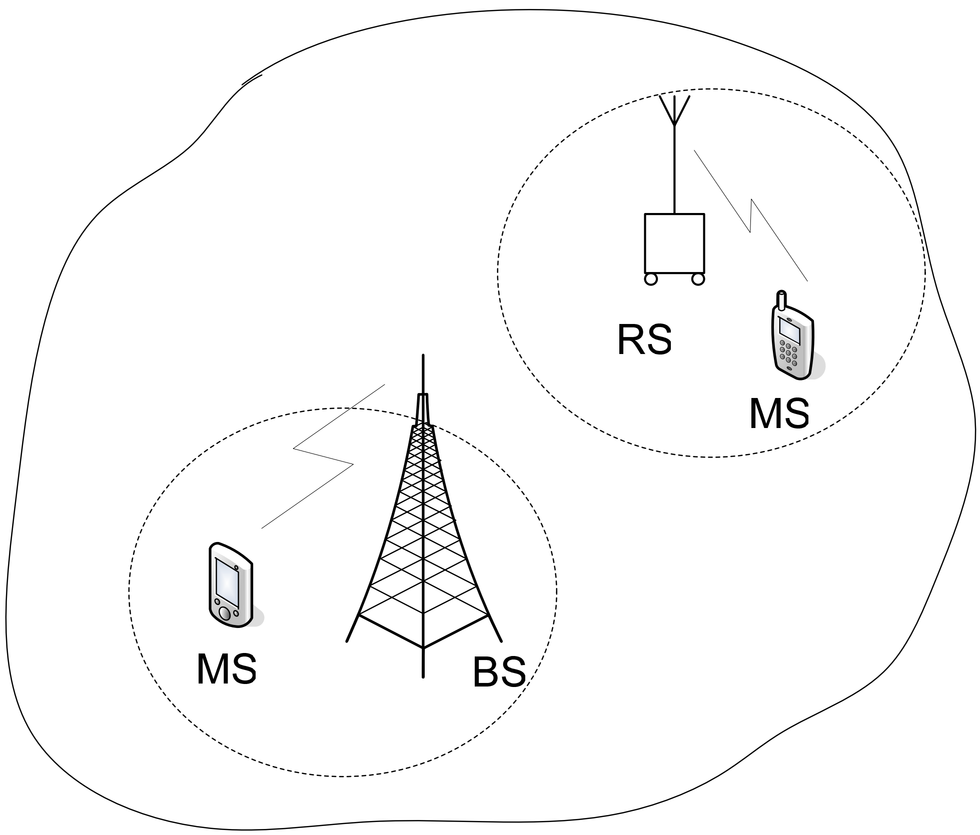

Figure 5 Simultaneous Transmission

The following example demonstrates the scenario for how the scheduler can assign resources. For simplicity, we only examine the scenario where each of the five MSs has one active connection for this particular frame. The network topology is shown in Figure 6, and Figure 7 depicts how the scheduler could assign the resources.

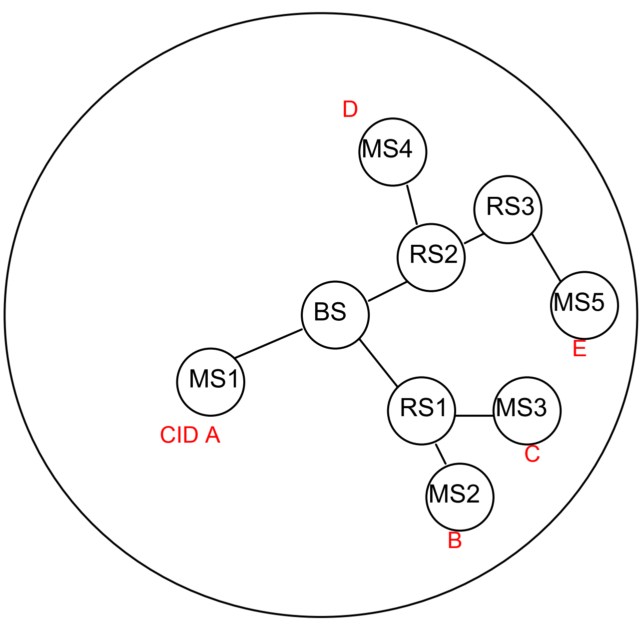

Figure 6 Network Topology Example

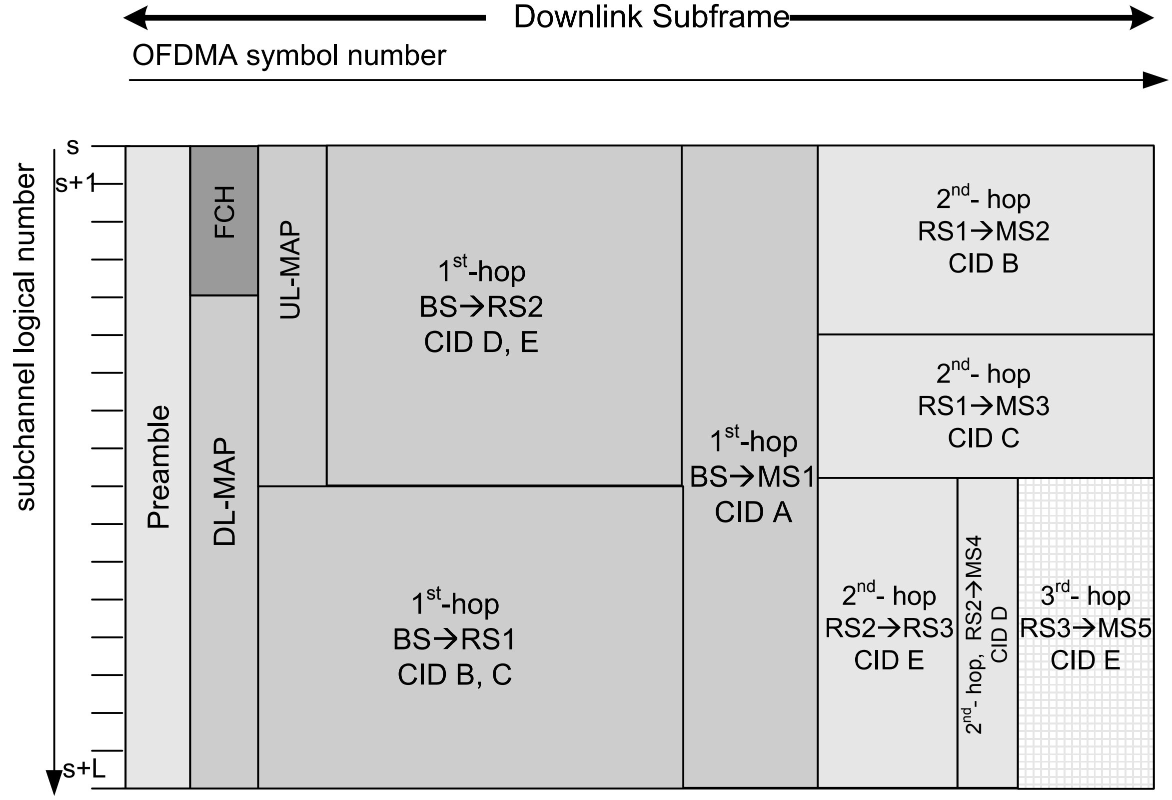

Figure 7 Frame Structure of network topology shown in Figure 6.

Cooperative relaying, for CID B for example, may be enabled by allowing the BS to transmit the same information as RS1 for the burst containing CID B. Simultaneous transmission may be enabled by allowing different bursts to overlap, under the assurance that the receiver nodes are sufficiently separated.

5 Frame Structure Supporting Three Hops

Figure 8 depicts the scenario for three hops, and the three-hop extension of the frame structure is shown in Figure 9 as well.

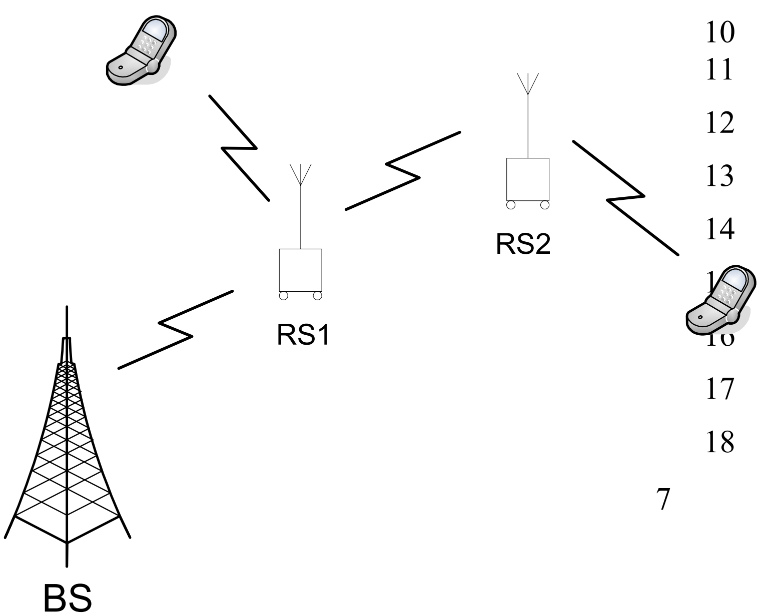

Figure 8 Three-hop Relay System

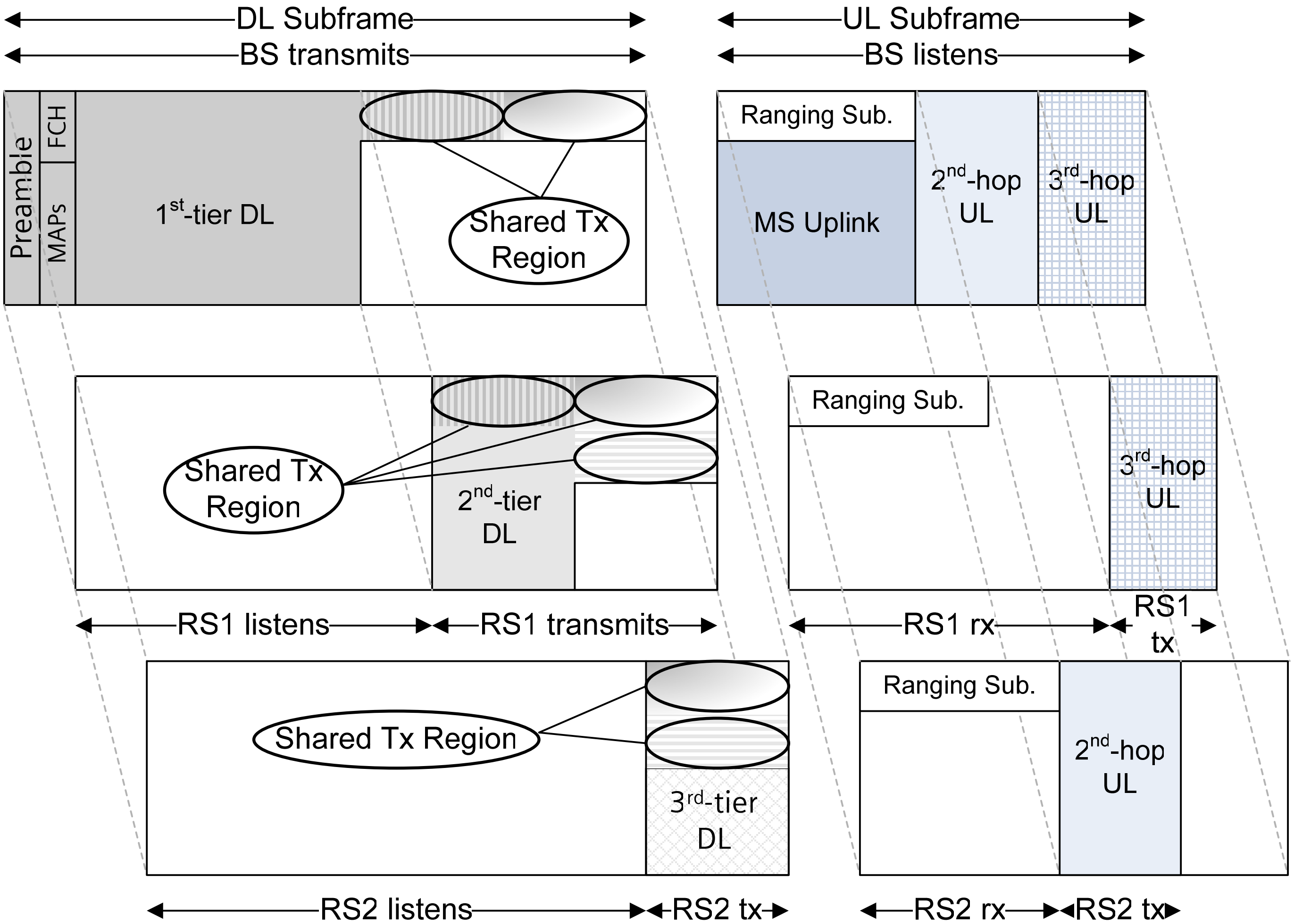

Figure 9 Frame Structure of Three-hop Relay System

6 Proposed Text

[Add the following text into section 8.4.4.8]

8.4.4.8 Relaying frame structure

In TDD relaying systems, the BS can transmit during the entire DL subframe. During the first part of the subframe, the resources are used solely for 1st-tier transmissions (i.e. BS-MS or BS-RS). During the second part of the downlink subframe, the resources can be used for both 1st-tier transmissions and 2nd-tier transmissions (RS-MS, RS-RS). During the third part of the downlink subframe, the resources can be used for 1st-tier, 2nd-tier and 3rd-tier transmissions (RS-MS, RS-RS).

Unlike the DL subframe, the UL subframe is divided into two zones by time division. The first zone is dedicated for MS uplink transmissions, and includes the ranging subchannel. In the second zone (the second-hop zone), the RS forwards data to the BS. To provide backward compatibility to existing 802.16e devices, only the MS uplink region can be used for MS uplink transmission; the second-hop zone shall be inaccessible for MS's transmissions. The sizes of UL zones may vary in time to utilize bandwidth resources efficiently.

8.4.5.3 DL-MAP IE format

TBD

8.4.5.4 UL-MAP IE format

TBD

8.4.7 OFDMA ranging

Periodic ranging of the RS can be done over dedicated uplink bursts.

References

[1] IEEE C802.16j-06/050r4, “Proposed Technical Requirements for IEEE 802.16 TGj”.

[2] IEEE S802.16mmr-05/034r2, “Analysis of Simple Infrastructure Multihop Relay Wireless System”.