Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Multihop Relay frame structure**
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Re:	IEEE 802.16j-06/027, “Call for technical proposals regarding IEEE project P802.16j”
Abstract	Define relaying frame structure to support throughput enhancement and coverage extension relaying.
Purpose	For text changes in emerging amendment of IEEE 802.16e-2005 to support MMR functionality.
Notice	
Release	
Patent Policy and Procedures	

Multihop Relay frame structure

1 Introduction

This document proposes a TDD frame structure for MR network, to response to the Call for Contribution of IEEE802.16TG.

In MR-enable cell, one or several types of RS are introduced to improve coverage extension and/or throughput enhancement. The topology may be chain or tree. MR-BS and RS require an uniform frame structure to support different possible types of RSs.

In this document, we propose a TDD relaying frame structure to support both coverage extension relay and throughput enhancement relay, as well as to support both inband relay and out-of-band relay. This relaying frame structure is an extension of 802.16e OFDMA TDD frame structure.

2 RS classification

In this document, two types of relay are considered. One is the throughput enhancement relay, and the other is the coverage extension relay. They can coexist in one MR cell.

2.1 Throughput enhancement relay

Throughput enhancement relay station (TE-RS) generally deploys inside BS's coverage area, as in Figure 1, to improve throughput of the area. TE-RS relays all data and unicast control messages between MR-BS and MS, excluding downlink broadcast control information, e.g. frame preamble, FCH and MAPs. MS can directly receive frame preamble, FCH and MAPs from MR-BS. TE-RS does not broadcast frame preamble, FCH and MAPs to its MS. Through introducing TE-RS, original low order modulation and coding scheme (e.g. BPSK and QPSK) over one hop (BS-MS) is replaced by high order scheme (e.g. 16-QAM, 64-QAM, and 128-QAM) over two hops (BS-RS and RS-MS). TE-RS always work at same RF channel with its upstream node (MR-BS or CE-RS).

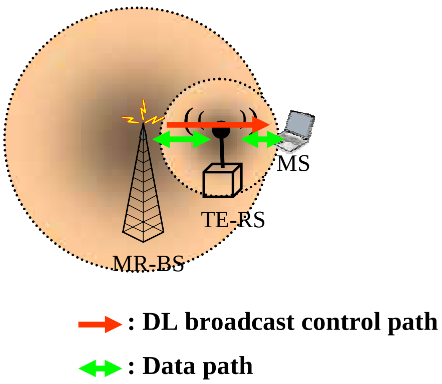

Figure 1 Throughput enhancement relaying

2.2 Coverage extension relay

Coverage extension relay station (CE-RS) is often located at the edge of MR-BS's coverage area, as shown in Figure 2, or out of the BS coverage. It's mainly used for coverage extension. But it also can be used to enhance throughput in some cases. CE-RS relays all data and all control messages between MR-BS and MS. Comparing with TE-RS, CE-RS shall broadcast downlink broadcast information at the beginning of a frame, including frame preamble, FCH and MAPs. CE-RS may work at same RF channel, and simulcasts same frame preamble, FCH and MAPs with MR-BS. CE-RS may also work at different RF channel with MR-BS and broadcast its own frame preamble, FCH and MAPs.

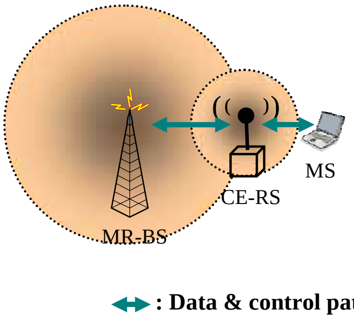

Figure 2 Coverage extension relaying

3. TDD relaying frame structure definition

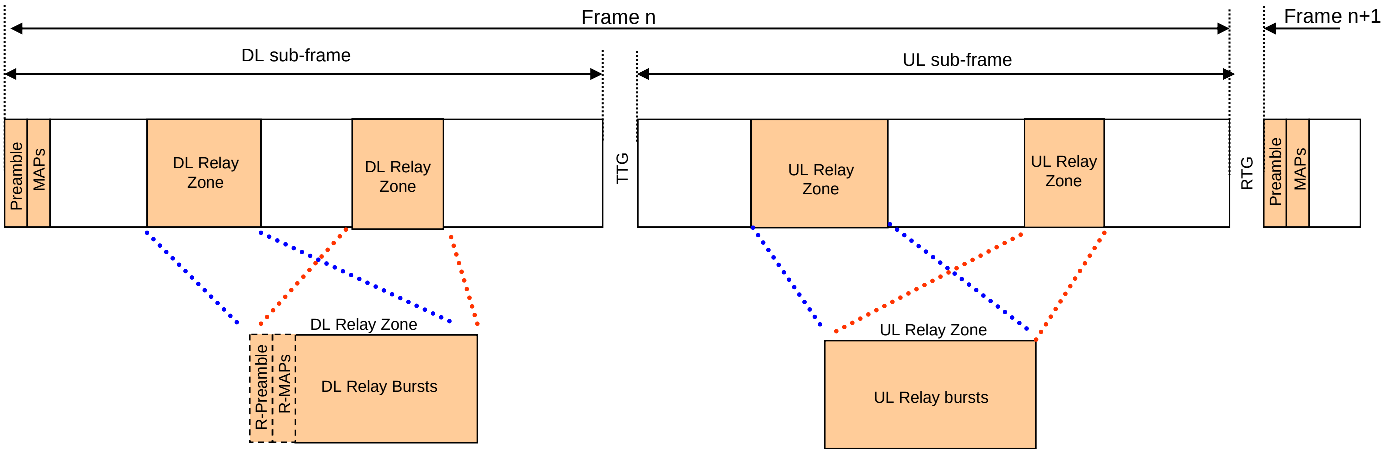

Figure 3 TDD relaying frame structure definition

The proposed TDD relaying frame structure is illustrated in Figure 3. DL relay zone and UL relay zone are defined in DL sub-frame and UL sub-frame, respectively. These relay zones are used for communication between MR-BS and RS, or between two RSs. One frame may have multiple pairs of relay zones for supporting multiple hop relaying. A relay zone occupies continuous OFDM symbols. In general, RSs with same hop count will be scheduled in the same relay zone. These RSs may work in time division multiplexing access or frequency division multiplexing access (OFDMA-based). Each RS has its own relay burst in the relay zone. MR-BS may dynamically adjust position and size of relay zone and inform RS via MAC messages. In the case of coexistence of TE-RS and CE-RS, MR-BS will allocate them different relay zones.

The frame preamble and MAPs, at the beginning of frame, is backward compatible with 802.16e OFDMA frame. The frame preamble and MAPs are used not only by MS, but also by TE-RS. All MSs in one MR cell synchronize to the frame preamble at the beginning of the frame. MS bursts are allocated in frame MAPs, no matter its access station is BS or RS. TE-RS also synchronizes with MR-BS via the frame preamble and get MAP information from it. When MR-BS and CE-RS work at same RF channel, they simulcast same frame preamble and MAPs. When MR-BS and CE-RS work at different RF channels, they broadcast different preambles and MAPs. In this case, CE-RS generates its own MAPs.

The relay preamble (R-Preamble), relay MAPs (R-MAPs) and R-FCH of DL relay zone, are optional. They are only used for CE-RS relaying. R-preamble is for CE-RS synchronization with its upstream node, and it is transparent to MS. R-MAP gives relay burst definition. R-preamble and R-MAPs are broadcast by upstream node to downstream CE-RSs, such as MR-BS broadcasts to all 1-hop relays, all 1-hop relays simulcasts to all 2-hop relays, and so on.

In addition, in the frame structure, ranging channels are shared by RS and MS. RS can use it to receive ranging messages from its downstream node (MS or RS), and RS also can use it to send ranging messages to its upstream node (BS or RS).

4. .Examples of TDD relaying frame structure

This section gives several typical application cases based on this uniform TDD relaying frame structure. In RS network entry and initialization stage, RS should inform MR-BS its supported modes (TE or CE).

4.1 Throughput enhancement Example

Figure 4 is throughput enhancement with two TE-RSs.

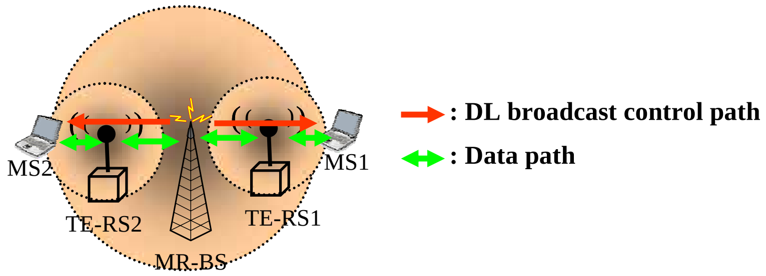

Figure 4 Throughput enhancement example

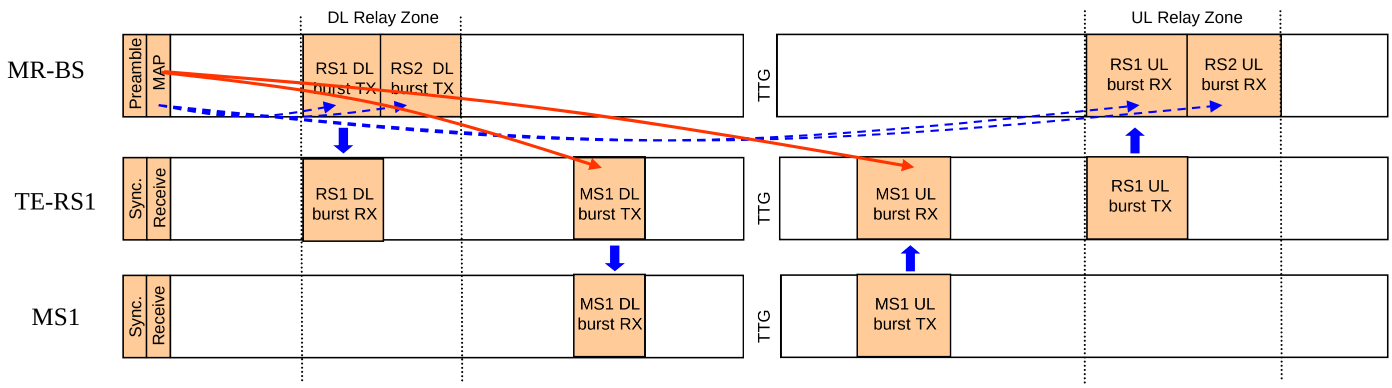

Figure 5 Frame structure for throughput enhancement

In this example, TE-RS bursts are defined by frame MAPs. Both TE-RSs synchronize with MR-BS through frame preamble. The relay bursts are allocated in TDMA mode. Actually, they also can also allocated in OFDMA mode. MS receives frame preamble and MAP from MR-BS directly. The common ranging channel is shared by all MSs and TE-RSs. Via this channel, TE-RS not only conducts initialization ranging but also receives ranging messages from MS.

4.2 Coverage extension example

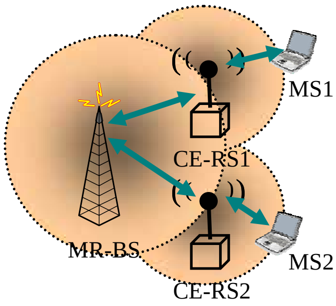

Figure 6 Coverage extension example

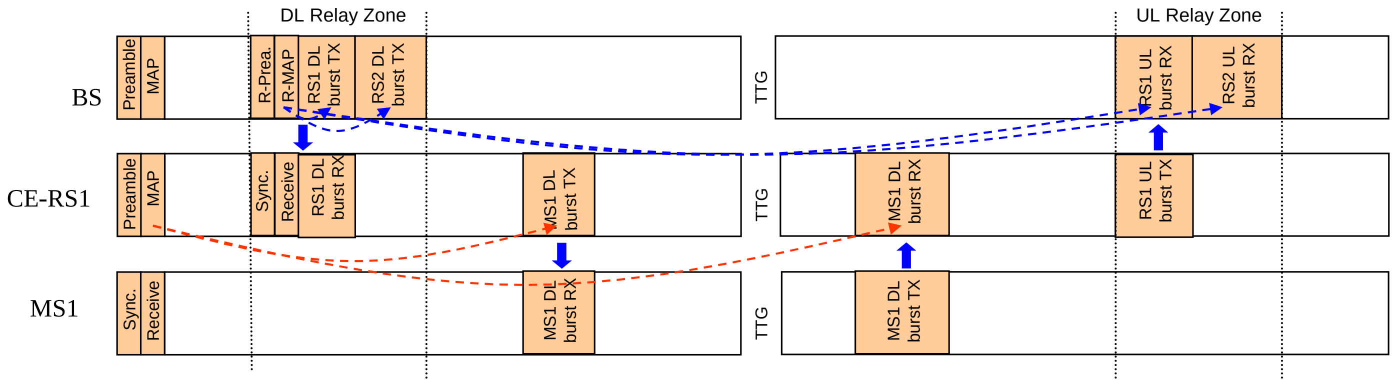

Figure 7 Frame structure for coverage extension

Figure 6 and 7 give coverage extension example and its frame structure. Both CE-RS1 and CE-RS2 are 1-hop RS. In this case, together with MR-BS, CE-RS1 and CE-RS2 simulcast same frame preamble and MAPs in same RF channel. All MSs synchronize to one time point. Either it accesses to MR-BS or to CE-RS. MR-BS broadcast R-preamble and R-MAP to CE-RSs. The R-Preamble is newly defined preamble, which is transparent to MS and does not impact on MS behavior. R-MAP is new MAC management message. The relay zone position and size is controlled by MR-BS. Before/behind each relay zone, RS-TTG and RS-RTG gaps shall be reserved for RS transition between transmit mode and receive mode.

4.3 Multihop (3-hop) coverage extension example (with same RF channel)

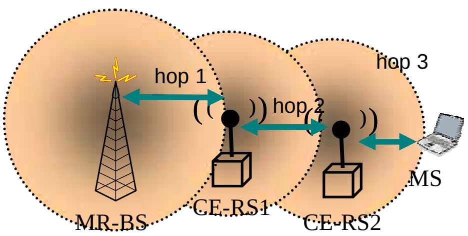

Figure 8 Inband multihop coverage extension

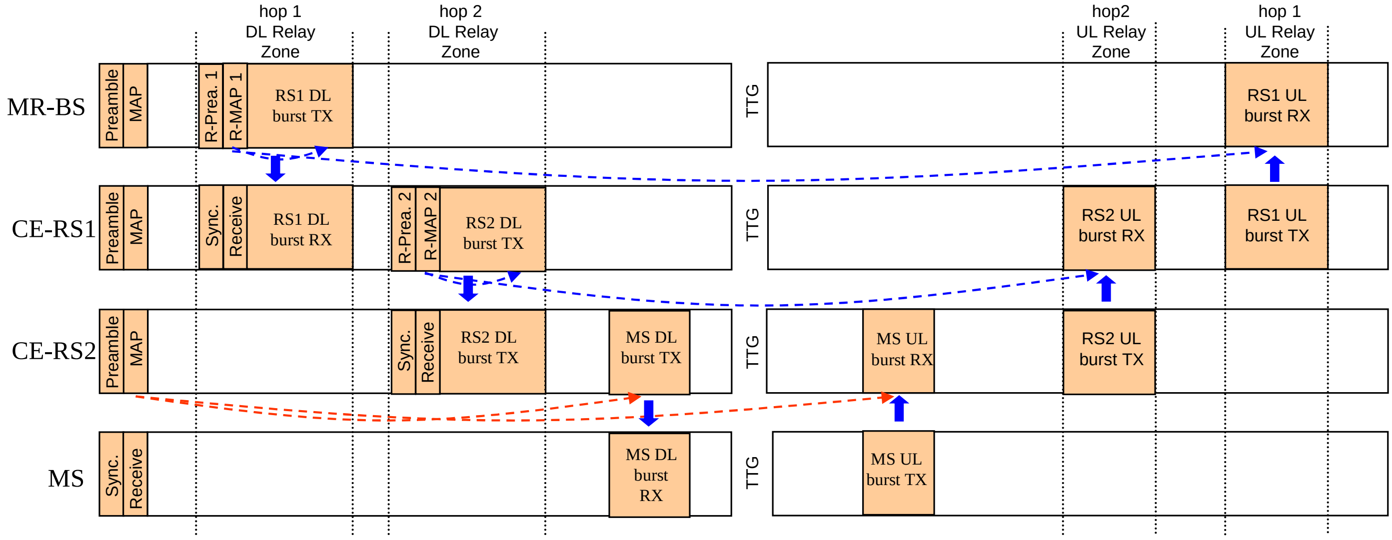

Figure 9 Frame structure of inband multihop coverage extension

Figure 8 and 9 give same frequency multihop relaying extension example. At the beginning of any frame, MR-BS, 1-hop CE-RS and 2-hop CE-RS simulcast same frame preamble and MAP in same radio channel. MR-BS broadcasts R-preamble-1 and R-MAP-1 to all 1-hop CE-RSs. 1-hop CE-RSs simulcast R-preamble-2 and R-MAP-2 to all 2-hop CE-RSs. For each hop, there should be specific R-preamble. The hop count decides how many R-preamble should be used in MR-cell. In order to reduce traffic delay for multihop application, in downlink, hop-1 relay zone is scheduled before hop-2 relay zone, but in uplink hop-1 relay zone is scheduled after hop-2 relay zone.

4.4 Multihop (3-hop) coverage extension example (with different RF channel)

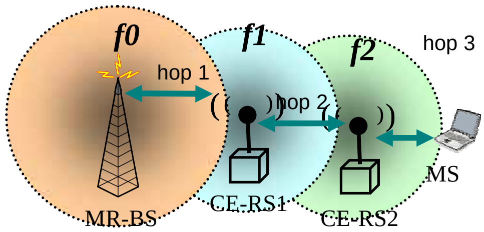

Figure 10 Different frequencies multihop coverage extension

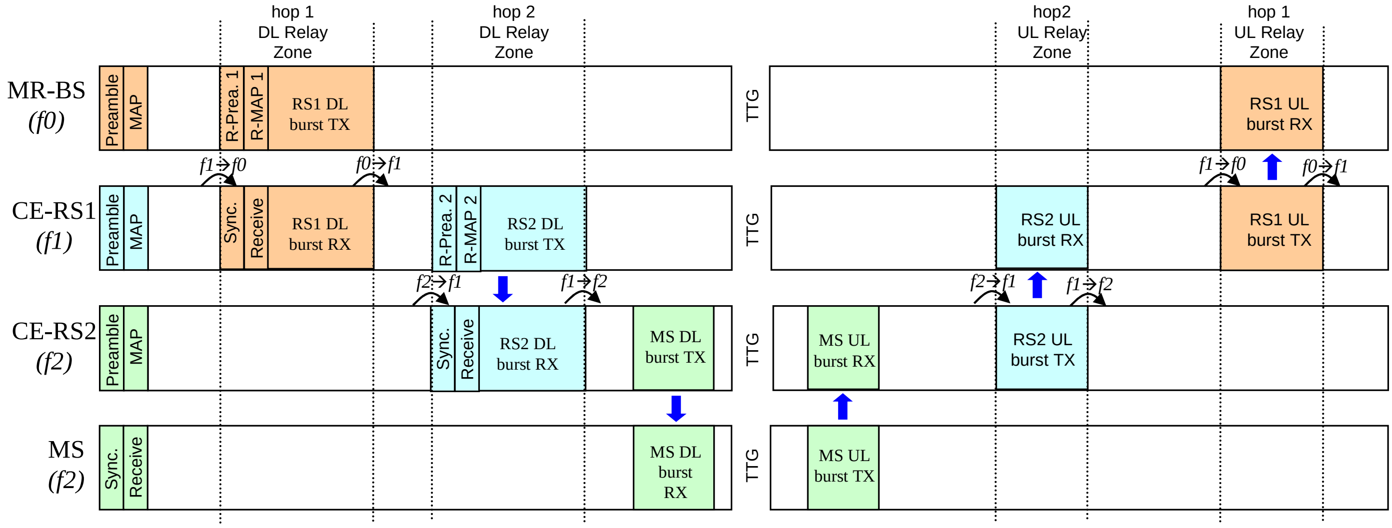

Figure 11 Frame structure of out-of-band multihop coverage extension

Figure 10 and 11 give out-of-band multihop relaying extension example. MR-BS and CE-RS have their own radio channels (different carriers, or different OFDMA segments) for MS access. Relaying transmission uses the radio channel of upstream node (MR-BS or CE-RS). CE-RS will work at two frequencies and perform frequency switching operation when communication with upsteam/downstream node in relay zone. As a example, CE-RS 1 use f1 for relaying and f2 for MS access, it need frequency switching to send/receive relay bursts in hop-1 or hop-2 relay zones. Because MR-BS and CE-RS have different radio channel, at the beginning of frame, they can broadcast different frame preamble and MAPs without any interference each other. Each CE-RS is responsible for its owned MS access and define its dedicated ranging channel.

4.5 CE-RS and TE-RS coexistence example

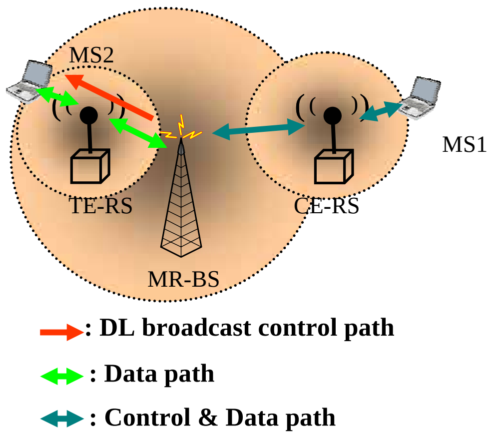

Figure 10 CE-RS and TE-RS coexistence example

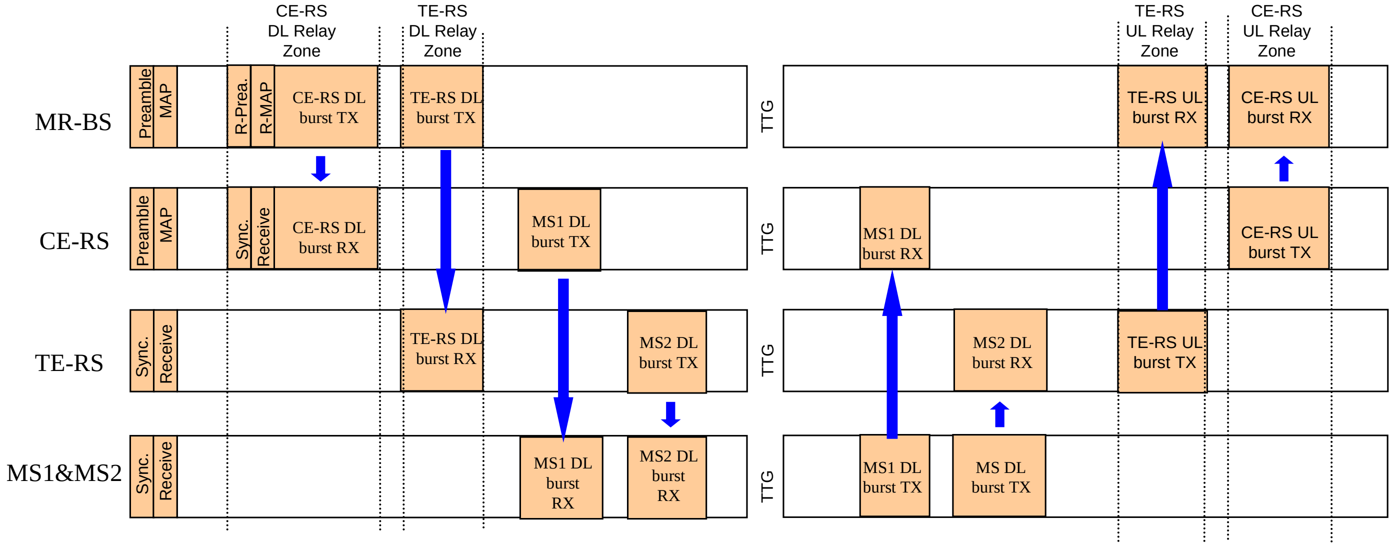

Figure 11 Frame structure for hybrid application

Figure 11 illustrates the proposed frame structure of the hybrid case in which CE-RS and TE-RS coexist in one MR cell. CE-RS and TE-RS occupy different relay zones.

[Reference]

[1] IEEE C80216mmr-05_023, "Recommendation on 802.16 MMR with Backward Compatibility"
[2] IEEE C80216mmr-05_025, "A frame structure for mobile multi-hop relay with different carrier frequencies"
[3] IEEE C802.16j-06/004r1, " Recommendations on IEEE 802.16j "