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| Re: | A response to a Call for Technical Proposal, http://wirelessman.org/relay/docs/80216j-06_034.pdf |
| Abstract | In this contribution, we study the location of the RS-Preamble introduced in C-802.16j-2006/241r1. |
| Purpose | To incorporate the proposed text into the P802.16j Baseline Document (IEEE 802.16j-06/026r1) |
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# Location of the RS-preamble

*Israfil Bahceci, Hang Zhang, Peiying Zhu, Mo-Han Fong, Wen Tong, David Steer, Gamini Senarath, Derek Yu, Mark Naden, G.Q. Wang*

## 1. Introduction

In [1], we introduce a RS-preamble to be transmitted periodically for the purposes of

- Downlink synchronization (Nortel [1] , Fujitsu [2]): RS(s) transmitting their own preambles will not be able to receive the 802.16d/e preamble for synchronization
- Enabling the RS(s) and BS(s) to monitor the RS(s) and BS(s) in their coverage areas (Nortel [1], Fujitsu [2]).

For proper monitoring, it is preferred to have a network-wide fixed RS-preamble location. This limits the number of searching candidates for its location; hence reduces the complexity of monitoring. In addition, the orthogonality of RS-Preambles will improve the signal measurement accuracy. Furthermore, a similar measurement procedure for MS could be reused.

The overhead and interference are two important factors impacting the selection of location. In this contribution, we investigate potential RS-Preamble locations along with their overheads and interference issues under network-wide fixed location constraints and no modification of 802.16e MS. The purpose of this contribution is to facilitate the selection of RS-Preamble location.

## 2. Issues on the RS-preamble Location

### *2.1 Overhead: TTG/RTG/OFDM Symbol durations*

For a rigorous understanding of the overhead incurred by the RS-preamble, we consider a typical WiMax deployment scenario with the following parameters (Table 1):

Table 1 Typical WiMax parameters for TTG/RTG/OFDM symbol period

| Parameter | Number of Samples | PS (Physical Slots) | Duration (μsec) |
|---|---|---|---|
| Bandwidth | 10 MHz | | |
| Sampling frequency | 11.2 MHz | | |
| FFT Size | 1024 | 256 | 91 |
| Cyclic Prefix | 128 | 32 | 12 |
| OFDM symbol | 1152 | 288 | 103 |
| TTG | 1184 | 296 | 105 |
| RTG | 672 | 168 | 60 |

It is clear that the TTGs and RTGs are comparable to the useful OFDM symbol duration; hence we may end up with low bandwidth efficiency if too many transitions from receive-to-transmit or transmit-to-receive are required.

## *2.2 Interference*

The choice of RS-preamble location is also affected by the interference between nearby or adjacent base stations. If an 802.16d/e BS and 802.16j MR-BS are close to each other, the UL signals from MS(s) served by the 16e BS and from MS(s) directly served by 16j MR-BS (i.e., single hop between MS and MR-BS) may interfere. A relatively less severe effect occurs also in the DL transmission. We can have the schedulers reserve the RS-preamble instances but that will further reduce the bandwidth efficiency since a large number of MS(s) may be affected.

# 3. RS-Preamble Locations

Under network-wide fixed location constraint, we better have the RS-preamble at the end of either the DL or UL sub-frames. DL/UL ratio remains same during a long period, e.g., quasi-static. Thus, the start or end of DL/UL sub-frames remains static as well. The DL frame already starts with 802.16d/e preamble and MS should not be modified, so it is not possible to include it after 802.16d/e preamble. The other locations require much overhead (for reconfiguring if necessary) and too much TTG/RTG. In the following sections, we consider potential RS-preamble locations along with their overhead and interference issues.

### *3.1 RS-Preamble in UL, before 802.16d/e preamble*

Figure 1 shows the case of transmitting the RS-preamble just before the 802.16d/e preamble. During the UL interval, a RS may be either in transmission mode or in receiving mode. In addition, a RS may be either transmitting its RS-preamble or monitoring others' RS-preambles. These cases are explicitly depicted in Figure 1.

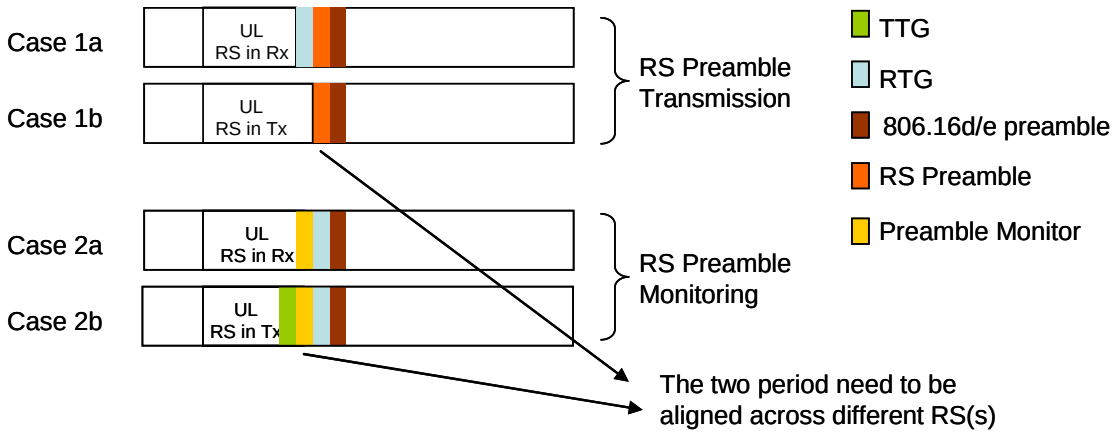


Figure 1 RS-preamble in UL, before 16d/e preamble

Clearly, the minimum time required for the RS-preamble is given by:

$$T = 1 \max (TTG,RTG) + 1 \text{ OFDM Symbol} + 1 RTG$$

## *3.2 RS-preamble in UL, 1 OFDM Symbol offset from 802.16d/e preamble*

In figure 2, we consider the case where the RS-preamble appears exactly at the second OFDM symbol before the 16d/e preamble. This case differs from the previous case in that the RTG is absorbed by the OFDM symbol after the RS-preamble. *Note that this technique is possible only if the RTG is less than the OFDM symbol duration*. Therefore, minimum time required for the RS-preamble transmission is given by:

$$T = 1 \max (TTG,RTG) + 1 \text{ OFDM Symbol} + 1 \max (RTG,\text{OFDM Symbol})$$

On the other hand, with the integer offset method, we have

$$T = 1 \max (TTG,RTG) + 2 \text{ OFDM Symbol}$$

For the deployment scenario in 2.1, RTG is less than OFDM Symbol duration, so this method is acceptable.

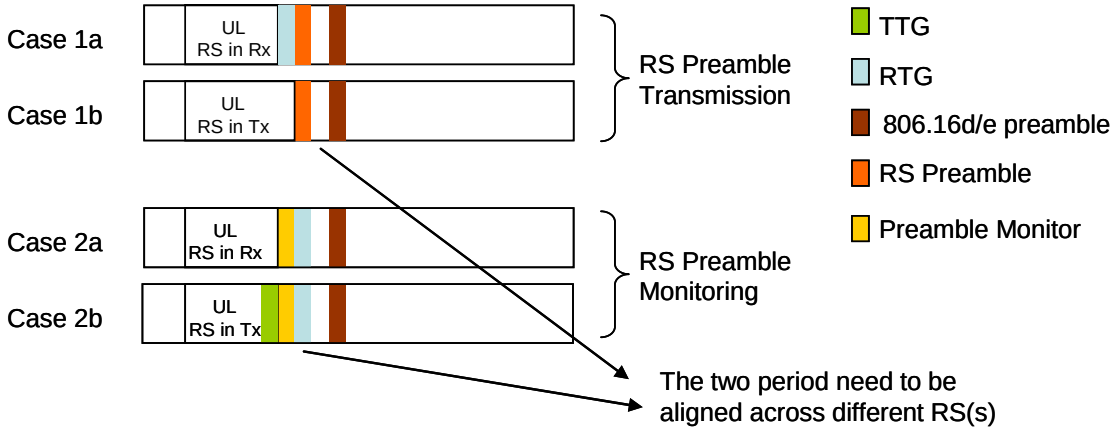


Figure 2 RS-preamble in UL, 1 OFDM symbol offset from 16d/e preamble

Note that the RS-Preamble transmissions in UL Zone may suffer from interference, in particular, for the 16d/e BS(s) located nearby 16j MRBS(s). For example, if the MRBS and the BS are on the same tower, the preamble transmission from MRBS in the UL may interfere with the MS(s) transmission served by the BS. On the other hand, with the integer offset from the 802.16e preamble, frame-alignment and synchronization becomes easy.

## *3.3 RS-preamble in the last OFDM symbol of the DL Zone*

The RS-preamble transmission in DL Zone is presented in Figure 3. In this case, we may need either RTGs or TTGs after the RS-preamble. Thus, the minimum time is

$$T = 1 \max(TTG,RTG) + 1 \text{ OFDM\_Symbol} + 1 \max(TTG,RTG)$$

For the scenario of 2.1., we have T = 2 TTG + 1 OFDM Symbol. Since TTG is larger than RTG, RS-preamble transmission in the DL Zone requires more bandwidth than required for the UL Zone case. Furthermore, if DL/UL ratio changes, we have to update the location of the RS-preamble across the network. The interference is not severe for this case.

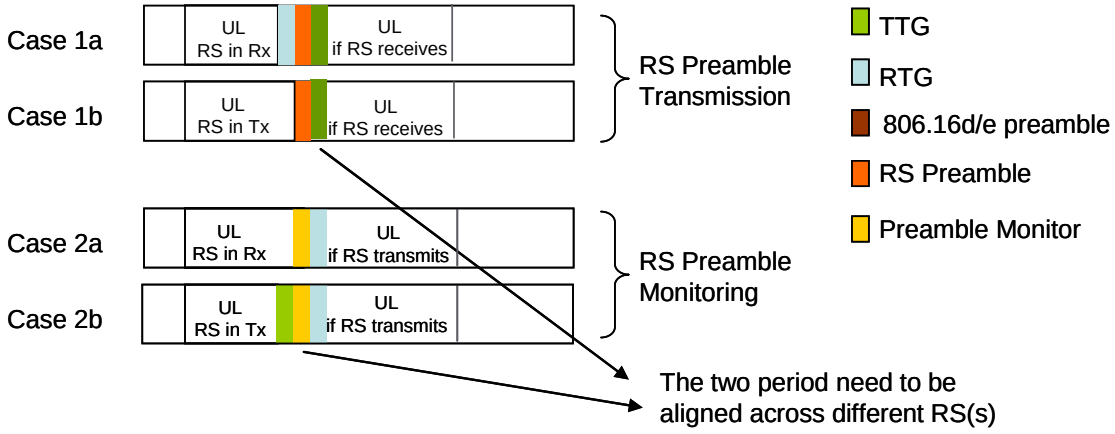


Figure 3 RS-preamble in DL Zone

For the RS-preamble in the DL, the synchronization process may require additional complexity since the RS-preamble is neither at the beginning of the frame nor at the end of the frame.

Table 2 summarizes the alternative locations together with their advantages and disadvantages.

Table 2 Alternative RS-preamble Locations

| **Preamble Location** | **Pros** | **Cons** | **TTG/RTG requirement** |
|---|---|---|---|
| Just before the 802.16d/e preamble | - less time spent for Rx-Tx or Tx-Rx transition gaps | - Two ambles one after each other (possible confusion at the MSs if not good PN sequences available or same PN sequences are employed)<br>- MR-BS or RS transmitting RS preamble (now in the UL) may interfere with the neighboring 16e BS | - Minimum time: 1 TTG + 1 RTG + 1 OFDM Symbol |

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| | | receiving from MSs | |
| UL Zone, at the second OFDM symbol before the 806.16d/e preamble (Nokia) | - Continuous transmission for BS in the DL subframe<br>- RS-preamble aligned with respect to the 802.16d/e preamble | - loss in the bandwidth efficiency (one OFDM symbol just before the 802.16d/e preamble is used as a gap)<br>- MR-BS or RS transmitting RS preamble in the UL may interfere with the neighboring 16e BS receiving from MSs | - Consumed time<br>1 TTG + 2 OFDM Symbol<br>- Minimum time required: 1 TTG + 1 max(RTG,OFDM symbol) + 1 OFDM Symbol<br>-RTG must be less than OFDM Symbol time |
| Last OFDM symbol of the DL Zone | - A short MAP_IE can be used for accurately locating the preamble, e.g., at some fixed offset from the 802.16d/e preamble | - As DL/UL ratio changes, difficult to maintain the update of location<br>- Requires TTG/RTG at the BS if BS wants to monitor RS-preamble<br>-Frame synchronization is more difficult<br>- Collision with the optional Common SYNCH preamble every 4 frame | - Minimum time:<br>2 TTG + 1 OFDM Symbol |
| After a fixed integer number of OFDM symbol duration from 802.16d/e frame start preamble, e.g., around the middle of the frame | - a constant location relative to the 802.16d/e preamble | - to much RTG/TTG may be required<br>- difficult to handle since DL/UL ratio changes<br>- complicates the synchronization: because of TTG/RTG, the offset from the 802.16d/e preamble is not trivial | |
| UL Zone, just before the 802.16d/e preamble, occupying half of the standard OFDM symbol duration | - higher bandwidth efficiency | - higher implementation complexity because of the change in OFDM symbol duration<br>- difficult to make use of the remaining half of OFDM symbol period<br>- MR-BS or RS transmitting RS | - Minimum time:<br>1 TTG + 1 RTG + 1/2 OFDM Symbol |

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| | | preamble in the UL may interfere with the neighboring 16e BS receiving from MSs | |

## 4. Conclusions

In the case of DL Zone RS-preamble, we need 2 TTGs which is higher bandwidth consuming than the UL Zone case requiring 1 TTG + 1RTG. However, the UL Zone RS- Preamble is subject to the BS-BS interference that can be caused by the heterogeneous deployment of 16e and 16j. If the interference can be managed, we suggest the transmission in the UL Zone, at the last OFDM symbol. If not, it should be transmitted at the last OFDM symbol of the DL Zone. The PN sequence design for the RS-preamble is FFS.

## 5. Text Proposal

Insert the following subclause:

++++++++++++++++ *start text* ++++++++++++++++++++++++++++++++++++++++++++

8.4.4.8.1.1 RS-preamble location

"…The location of the RS-preamble shall be network-wide the same across all RS(s) and MRBS(s), and shall be reconfigurable. The RS-preamble shall occupy the last OFDM symbol of the UL Zone or DL Zone. For RS-preamble in the UL Zone, at least 1 TTG before the preamble and at least 1 RTG after the preamble shall be inserted. For the case RS-preamble in the DL Zone, 1 TTG both before and after the preamble shall be inserted. The optional Common_Synch preamble of the 802.16e shall not be transmitted if the RS-preamble is in the DL Zone. The modulation for the RS-preamble is the same as that used by the 802.16d/e preamble. Table xxx shows the PN sequences to be used in the RS-preamble symbol."

++++++++++++++++ *end text* ++++++++++++++++++++++++++++++++++++++++++++

### *References*

[1] Hang Zhang, et al., IEEE C802.16j-06/240 " RS DL Synchronization and Radio Environment Measurement - Introduction of RS-Preamble", available at http://www.ieee802.org/16/relay/contrib/C80216j-06_240.pdf

[2] Mike Hart, et al., IEEE C802.16j-06/144, "Relay midamble", available at http://www.ieee802.org/16/relay/contrib/C80216j-06_144.pdf