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Re:	Call for technical proposals regarding IEEE project P802.16j
Abstract	This contribution proposes a simple method of deriving postamble sequences using the existing preamble sequences and a PN sequence from PRBS
Purpose	
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Postamble sequence design for supporting relay zone synchronization

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Introduction

Similar to the frame start preamble in the access link, it is argued in [1] that an amble is required for the relay link for enabling synchronization. It is further argued that an appropriate location of the amble is at the end of the relay zone, i.e. a postamble. When the BSs and the RSs use the 802.16e preamble in the access zone, using the exact same preamble in the relay zone may cause malfunctioning in the legacy MSs as they may start detecting a dual correlation peak within the duration of a single frame. If amble sequences, different from the access zone preamble sequences can be used for the postamble, then the aforementioned problem can be alleviated.

In order to avoid definition of brand new sequences for the postamble, to accommodate "inexpensive" relay stations with constrained storage for example, this contribution proposes a method to derive postamble sequences using the current preamble sequences modified using simple methods.

Design considerations

- Reuse the preamble sequences defined in the current specifications.
- Autocorrelation performance comparable to that of the currently defined preamble sequences
- Superior cross correlation performance so as to maximally mitigate false alarms at the legacy MS.
- PAPR performance comparable to that of the 16e preamble.

Postamble generation in relay zone

Figure 1 shows a basic multihop scenario employing a postamble for BS-RS or RS-RS synchronization.

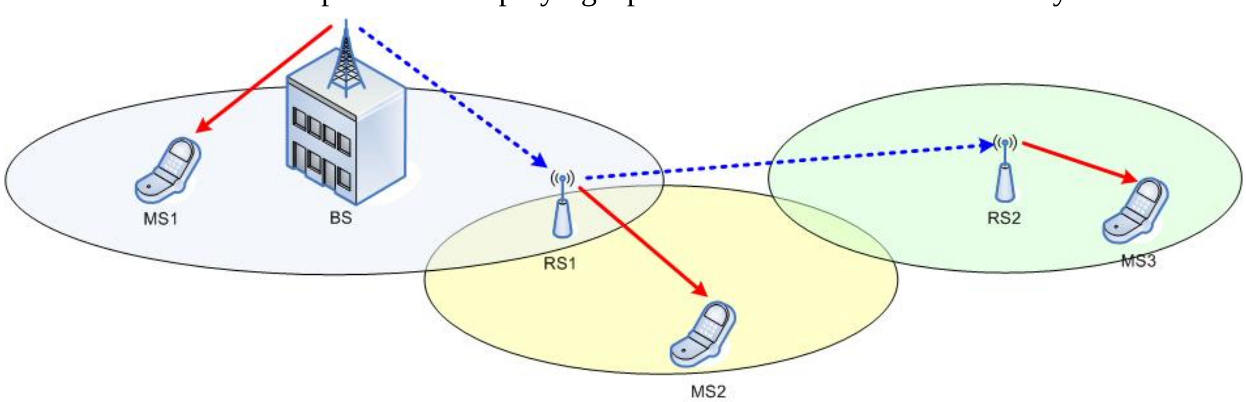

Figure 1. Basic multihop scenario employing a postamble (red: access link, blue: relay link)

For the reasons introduced earlier, postamble sequence for the relay zone should be different from the amble in the access zone.

In this document, the method for generating postamble sequences is proposed using the existing 16e sequences. In the current 16e system, PRBS generator for pilot sequence is defined in [2] and [3]. When an RS is installed in an MR-BS cell, the RS shall also have PRBS generators for generating its own pilot sequences for serving its mobile station.

The basic idea of making postamble sequence is as follows: If RS performs an exclusive OR(XOR) operation between a DL preamble and a PN sequence from the PRBS generator, as many new PN sequences can be generated as the DL preamble sequences. The new sequence has a rather low correlation with the DL preamble and the original PN sequence from PRBS, while maintaining the same autocorrelation performance as the usual PN sequences.

Figure 2 shows the postamble sequence generation example when the FFT size is 2048, j is the sequence index depending on preamble index. Whenever a BS needs a postamble, a new sequence can be generated easily by simply applying an XOR operation with the DL preamble and a PN sequence from PRBS determined by the IDcell and the Segment. IDcell and the Segment are deterministic values which dependent on the preamble index.

When the next hop RS receives this postamble, they can detect this new sequence because they already know the preamble index of their serving BS or the subordinate RS from the initial cell acquisition process.

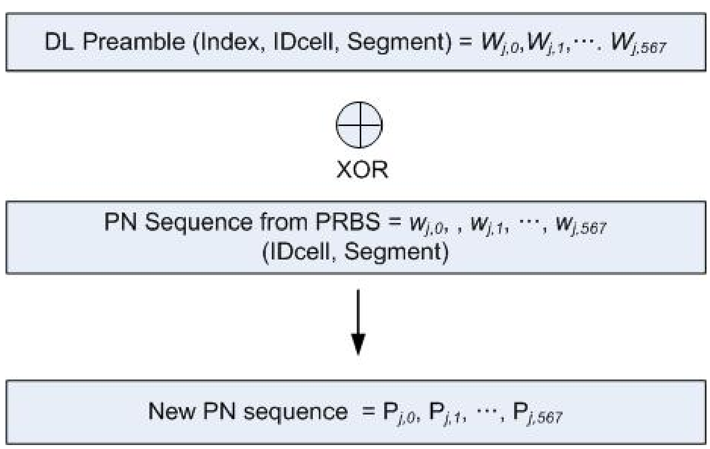

Figure 2. Postamble sequence generation

Tone reservation method for PAPR reduction

16e DL preamble has good PAPR characteristics. This allows the BS to boost the DL preamble power compared to the DL data burst. However, postamble sequences, that are obtained as described above, will have worse PAPR characteristic than the DL preamble because this sequence is just a PN sequence not optimized for PAPR. In order to enhance the PAPR performance, a tone reservation method in [4] is introduced.

Figure 3 shows the postamble sequence where some portions of the sequence is reserved for PAPR reduction.

Assume that N is the number of fixed sequences in the original postamble sequence; M is the number of reserved tones for PAPR which can be any binary values depending on PAPR value. The tones for PAPR also could be distributed as shown in Figure 4. In general, this distributed type is better for the PAPR performance than the fixed style shown in Figure 3. In Figure 4, reserved tones are represented simply by Ak+B. When 10% of tones are reserved for PAPR reduction, A= 10, B = one of values in {0, 1, 2, …, 9}

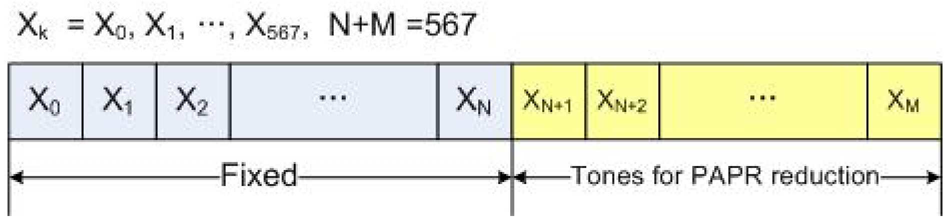

Figure 3. Postamble sequence applying tone reservation for PAPR reduction

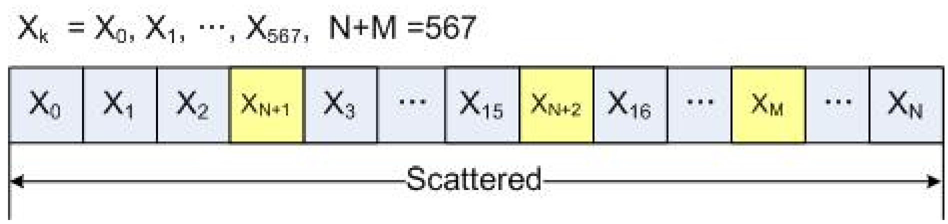

Figure 4. Postamble sequence applying scattered tone reservation for PAPR reduction

An example postamble sequence generation in a transmitter

This section describes an example of postamble sequence generation, which is derived from the frist preamble sequence defined in [2].

Index	IDcell	Segment	Series to modulate (W_k)	PAPR (informative)
0	0	0	0xC12B7F736CFFB14B6ABF4EB50A60B7A3B4163EA3360 F697C45075997ACE17BB1512C7C0CEBB34B389D8784553 C0FC60BDE4F166CF7B04856442D97539FB915D80820CED D858483	4.33

The first preamble sequence of 2048 FFT, W_0, is the above table.

The PN sequence having same length with preamble sequence can be generated from PRBS defined at Figure 262 in [3].

w_0={0xF40482D132BF08653E38DB76D5B06E3ADA365DE54E0EC6BB8AB40C87D313EB88B54C0F86 33DF94389B5EC4BACA3C59A7E70F665FE40E86939BBEA881508251629D1D2D333FF803}

The new PN sequence is derived by exclusive OR operation with above two sequences: $p_0 = W_0 \oplus w_0$

p_0={0x352FFDA25E40B92E548795C3DFD0D9996E2063467801AFC7CFB355107FF29039E460738AD86CDF0006D940EFF6339FAC3940703313BECEC5DF933FD2CF3B44BA953DE3EEBA7C80}

The PAPR of p_0 is 9.346. For PAPR reduction, the transmitter can generate a modified sequence p'_0, using the tone reservation method mentioned earlier.

When 10% of subcarriers (=56 tones) are reserved for PAPR reduction, and distributed type is applied every 10 tones, p'_0 can be obtained from p_0.

p'_0 ={0x252BFDA21E50BD2E548785C7DED099996A2163467801AEC7CFB351107FB2803DE560339ADC6CDF4016DD41EFB6339BAC3940703312BE8ED5DB923FD2DF3F44BA953DE3EEBA3C80}

The PAPR of p_0 is 6.471. For tone reservation, 10k+4 with (k = 0, 1, 2, …, 55) is used. If transmitter wants even lower PAPR, more tones may be reserved.

The time correlation performance is the same as the one without tone reservation because the time repetition characteristic is not changed by tone reservation.

The correlation performance in frequency domain, however, decreases due to the tone reservation which is utilized for improving the PAPR. So, there exists a trade-off at the transmitter between obtaining a lower PAPR reduction and the resulting correlation characteristics.

Correlation performance in a receiver

Table 1 shows the postamble correlation performance compared with DL preamble. When normalized, the auto-correlation value is “1”. Cross correlation values for several different conditions are shown in the table.

	Preamble(W_0)	Postamble(p_0)	Postamble with tone reservation (p'_0)
Max cross correlation value with other preamble (W_1, W_2,… W_{113})	0.088	0.088	0.109
Max cross correlation value with postamble $(p_1, p_2, ..., p_{113})$	0.088	0.130	0.109
Max cross correlation value with postamble using tone reservation method $(p'_1, p'_2, ..., p'_{113})$	0.088	0.130	0.109
Correlation value with (p_0) without knowing the location of reserved tones	N/A	1	0.912

From the simulation results tabulated above, it can be seen that the cross-correlation value between the preamble and the postamble (or with tone reservation) is comparable to that between two preambles. The postamble reserving 56 tones slightly decreases the auto-correlation performance in a receiver without knowing the location of reserved tones. However, if more tones are reserved for PAPR reduction, the transmitter needs to inform the location and number of reserved tones for better correlation performance.

Proposed Text Change

[Insert the followings after the end of section 8.4.6.1.1.2:]

8.4.6.1.1.3. Postamble sequence for downlink relay zone

MR-BS or RS shall transmit an amble to subordinate RS for downlink synchronization. This amble is defined at the last symbol of the downlink relay zone, called postamble. The postamble of subcarrier sets and segment assignment is the same as the preamble in 8.4.6.1.1. The modulation of postamble is boosted BPSK in 8.4.9.4.3.3.

The PN series modulating the postamble carrier-set are defined as following equation.

$$P_j = W_j \oplus w_j \qquad \text{(xxx)}$$

P_j is a postamble sequence

W_j is a preamble sequence

w_j is a Pseudo random sequence from PRBS generator in the downlink at Figure 262 in 8.4.9.4.1

j is a sequence index

$\oplus$ is a exclusive OR operation of each sequence bit

W_j is defined in table 309, 309a, 309b and 309c for FFT sizes of 2048, 1024, 512, 128.respectively. w_j is a PN sequence from PRBS generator in the downlink defined in 8.4.9.4.1, whose value depends on the segment and IDcell of the preamble W_j. The length of w_j shall be equal to the length of W_j

The defined series P_j shall be mapped onto the postamble subcarriers in the ascending order.

Some portion of the postamble sequence may be reserved for PAPR reduction. . This reserved sequence may change a ‘0’ to a ‘1’ or a ‘1’ to a ‘0’ for PAPR reduction. The number of tones and location used for PAPR reduction is implementation specific. The reservation information may be sent to the subordinate RS in the DCD message

[Add parameter in table 358]

Table 359 – DCD channel encoding

Name	Type	Length	Value	Scope
Reservation bits for PAPR reduction	xx	3	Bits:#0-7bits: the number of reserved tones Bits:#8-15bits: "A" (in Ak+B) Bits#16-23bits: "B" (in Ak+B)	OFDMA

References

[1] C80216j-07_136, "On the use of postamble for the relay link", Jan. 2007.

[2] 802.16-2004, "IEEE Standard for Local and metropolitan area networks, Part 16: Air Interface for Fixed Broadband Wireless Access Systems", *IEEE Computer Society and the IEEE Microwave Theory and Techniques Society,* 1 Oct. 2004.

[3] 802.16e-2005, "Amendment 2: Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1", *IEEE Computer Society and the IEEE Microwave Theory and Techniques Society,* 28 Feb. 2006.

[4] Krongold, B.S.; Jones, D.L, "A new tone reservation method for complex-baseband PAR deduction in OFDM systems", *IEEE International Conference on Acoustics, Speech, and Signal Processing,* May. 2002