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Source(s)	Youngbin Chang, Changyoon Oh, Hyoung Kyu Lim, Jaeweon Cho, Jungje Son, Panyuh Joo Samsung Electronics 416, Maetan-3dong, Youngtong-gu, Suwon-si, Gyeonggi-do, Korea Rakesh Taori Samsung Advanced Institute of Technology Voice: +82-31-279-5519 Fax: +82-31-279-5130 mail to: yb.chang@samsung.com
Re:	Call for technical proposals regarding IEEE project P802.16j
Abstract	The sequence of DL synchronization symbol between MR-BS and RS can be generated from DL preamble and PRBS generator in RS.
Purpose	This contribution proposes the DL synchronization symbol sequence between MR-BS and RS
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Postamble sequence design for supporting relay zone synchronization

Youngbin Chang, Changyoon Oh, Hyoung Kyu Lim, Jaeweon Cho, Jungje Son, Panyuh Joo
Samsung Electronics
Rakesh Taori
Samsung Advanced Institute of Technology

Introduction

In [1], a postamble may be located at the end of relay zone for synchronization between MR-BS and RS or RS and RS. When MR-BS and RS uses 16e preamble in access zone, this 16e preamble cannot reused in relay zone because legacy MSs may feel constraint to synchronize with serving BS or RS due to two correlation peaks within 1 frame (e.g. 5ms). Therefore, the postamble needs some different sequences from the access zone preamble.

Design considerations

- Reuse current 16e features for minimizing overhead in RS, which means a brand-new postamble sequence table is a burden in RS.
- Correlation performance among postamble sequences shall be as much as 16e preamble sequences
- Cross correlation performance between 16e preamble and postamble shall be low for preventing legacy MS confusion.
- PAPR value of postamble may be low as much as 16e preamble.

Postamble generation in relay zone

The figure 1 shows a basic multihop scenario employing a postamble for BS-RS or RS-RS synchronization. BS or RS shall transmit DL preamble at the first symbol of every frame for DL synchronization with supporting MS transparency. As [1], BS or RS transmits a postamble for relay zone DL frame, DL preamble can not be reused because legacy MSs may feel constraint to synchronize with serving BS or RS due to two correlation peaks within 1 frame.

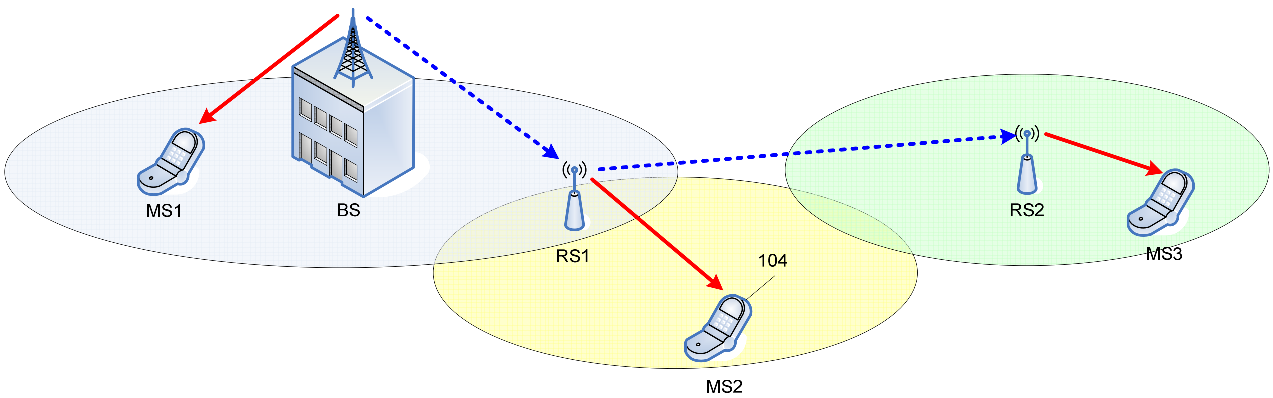

Figure 1. Basic multihop scenario employing a postamble (red: access link, blue: relay link)

Therefore, postamble sequence within relay zone shall be newly introduced. The number of postamble sequences may be as many as 16e DL preamble because BS or RS transmit DL preamble and postamble simultaneously within 1 frame.

In this document, the new postamble sequence is proposed using existing 16e sequences. In current 16e system, PRBS generator for pilot sequence is defined in [2], [3]. When the RS is installed in a BS cell, RS shall have PRBS generator for serving its mobile station.

The basic idea of making postamble sequence is as follows: If RS perform XOR operation between DL preamble and a PN sequence from PRBS, new PN sequences could be generated as many as DL preamble. This new sequence has no correlation with DL preamble and an original PN sequence from PRBS, and has the same autocorrelation performance as normal PN sequences.

Figure 2 shows the postamble sequence generation process when FFT size is 2048. When BS and RSs needs postamble transmission to downstream RSs within relay zone in PHY frame for DL synchronization, new sequence could be generated easily simply apply XOR operation with DL preamble and a PN sequence from PRBS determined by Cell_ID, Segment. Cell_ID and Segment are deterministic values depending on preamble index.

When the downstream RSs receive this postamble, they can detect this new sequence because they already know a preamble index of their BS or upstream RS during the initial entry process.

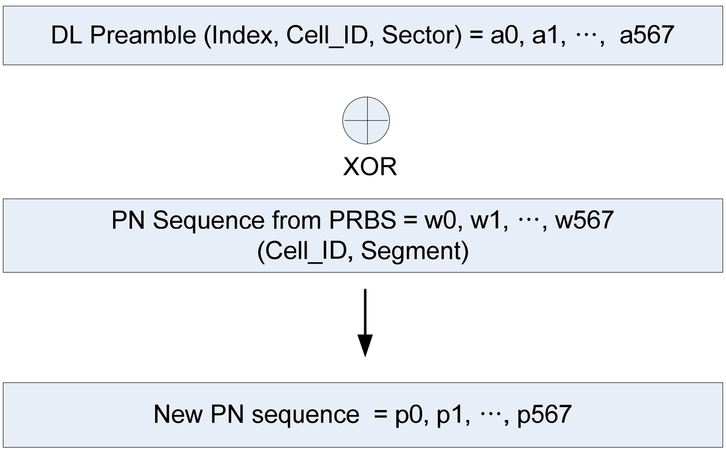

Figure 2. Postamble sequence generation

Tone reservation method for PAPR reduction

16e DL preamble has a good PAPR characteristic, so BS can boost DL preamble power more than DL data burst. However, above postamble sequence has worse PAPR characteristic than DL preamble because this sequence is normal PN sequence not being optimized PAPR. For solving this problem, tone reservation method in [4] is introduced for reducing PAPR of new postamble sequence.

The tone reservation method explains as follows:

Some parameters could be assumed to explain tone reservation method. In time domain, $\boldsymbol{x}$ is time sample vector, ***c*** is the peak cancellation sample vector. In frequency domain, ***X*** is discrete sequence vector on given OFDM subcarriers, ***C*** is tone reservation sequence vector. When X_k is the new PN sequence in Figure 2, C_k is the reserved tone for PAPR reduction, the modified PN sequence can be determined like equation 1.

$$\text{Equation 1:}\quad X_k + C_k = \begin{cases} X_k, & k \in D \\ C_k, & k \in D^c \end{cases}$$

Where, D represents the sequence-bearing subcarriers and D^c represents the available subchannels for PAPR reduction. The minimum PAPR can be obtained by solving for the C_k which minimizes the PAPR of ($\boldsymbol{x}+\boldsymbol{c}$).

$$\text{Equation 2:}\quad \min_{c}\{PAPR(x+c)\} = \min_{C}\{PAPR(IDFT(X+C))\}$$

There needs much complexity to find optimal ***C*** vector because it needs 2^d iteration search when the length of D^c is d. But if PAPR threshold value is determined, the sub-optimal ***C*** vector could be simply found using linear search.

Figure 3 shows the postamble sequence where some portions of sequence is reserved for PAPR reduction. Assume that N is the number of fixed sequences in 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 like Figure 4. In general, this distributed type is better PAPR performance than fixed style like 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}

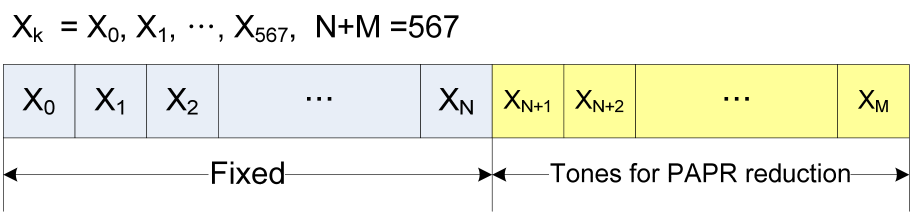

Figure 3. Modified postamble sequence applying tone reservation for PAPR reduction

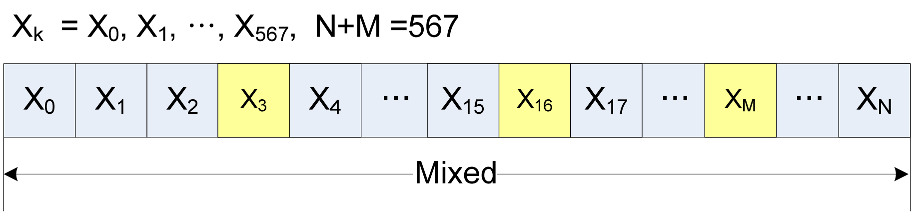

Figure 4. Distributed type sequence applying tone reservation method

Postamble transmission example in a transmitter

This section describes the example of postamble sequence generation and transmission in the BS or RS transmitter. For example, assume that BS transmits a postamble to subordinate RSs, where IDcell =0, Segment=0. In that case, the preamble sequence is used defined in [2].

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

The PN sequence could be generated from PRBS in defined [3].

$w_k = \{w_0, w_1, w_2, \ldots w_{567}\}$

={0xF40482D132BF08653E38DB76D5B06E3ADA365DE54E0EC6BB8AB40C87D313EB88B54C0F8633 DF94389B5EC4BACA3C59A7E70F665FE40E86939BBEA881508251629D1D2D333FF803}

The new PN sequence $p_k = W_k \oplus w_k$

$p_k = \{p_0, p_1, p_2, ..., p_{567}\}$

={0x352FFDA25E40B92E548795C3DFD0D9996E2063467801AFC7CFB355107FF29039E460738AD86C DF0006D940EFF6339FAC3940703313BECEC5DF933FD2CF3B44BA953DE3EEBA7C80}

The PAPR of p_k is 9.346. When BS doesn't need to boost postamble power, BS can transmit this p_k sequence. But if BS needs to boost postamble power, BS can regenerate p'_k using tone reservation method. Assume that 10% of subcarriers (=56 tones) are reserved for PAPR reduction, distributed type is applied every 10 tones and sub-optimal ***C*** vector is applied. p_k is changed into p'_k.

$p'_k = \{p'_0, p'_1, p'_2, ..., p'_{567}\}$

={0x252BFDA21E50BD2E548785C7DED099996A2163467801AEC7CFB351107FB2803DE560339ADC6 CDF4016DD41EFB6339BAC3940703312BE8ED5DB923FD2DF3F44BA953DE3EEBA3C80}

The PAPR of p'_k is 6.471. Tone reservation equation is used as 10k+4 (k = 0, 1, 2, …, 55). If transmitter wants more good characteristic of PAPR, more tone are reserved for PAPR or find more good sub-optimal ***C*** vector.

Postamble decoding example in a receiver

If RS knows the frame number and symbol location of postamble within DL relay zone, RS can synchronize with BS or upstream RS using postamble.

In that case, the time correlation performance is same as before tone reservation because time repetition characteristic is not changed after tone reservation.

However, the correlation performance in frequency domain decreased due to reserved tones for PAPR. In other words, more PAPR tones increase PAPR performance, more correlation performance decreases in proportional to PAPR tones. Therefore, there exists trade-off relationship between PAPR reduction and correlation performance. This is the implementation issue in transmitter.

In the receiver, time and frequency synchronization is implementation issue. When fewer tones are reserved for PAPR, transmitter doesn't needs to inform the location of reserved tones because correlation performance slightly worse than not applying tone reservation. However, when many tones are reserved for PAPR reduction, or serious noisy situation, there needs to inform the number of tones and location for better correlation performance. In this case, receiver does not use these reserved tones for calculating correlation.

Correlation performance in a receiver

When BS or upstream RS transmit postamble within DL relay zone, RSs can distinguish the postamble the other postambles from other BS or upstream RS. Hence, RS postamble need to guarantee the correlation perfromance in frequency domain.

When MS power on, it scan all of preambles every symbol by symbol. In that case, MS can detect both preamble and postamble due time correlation repetition characteristics. However, if the cross correlation characteristic in frequency domain is small as many as the other DL preamble between preamble and postamble, MS can detect correct preamble and get the cell acquisition instead of detecting postamble. Thus, the cross correlation performance between preamble and postamble is also important to keep MS transparency.

Table 1 shows the postamble correlation performance compared with DL preamble. When normalized auto correlation value is "1", several cross correlation values are shown in the table.

	Preamble(a_0)	Postamble(p_0)	Postamble with tone reservation (p'_0)
Max cross correlation value with other preamble (a_1, a_2,… a_{567})	0.088	0.088	0.109
Max cross correlation value with postamble $(p_1, p_2, ..., p_{567})$	0.088	0.130	0.109
Max cross correlation value with postamble $(p'_1, p'_2, ..., p'_{567})$	0.088	0.130	0.109
Correlation value with (p_0)	N/A	1	0.912

From the simulation results, cross correlation value between preamble and postamble (or with tone reservation) is as many as between preamble and preamble. The postamble reserving 56 tones slightly decrease auto correlation performance in a receiver.

4. 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

In DL relay zone, MR-BS or upstream RS shall transmit a postamble symbol within DL relay zone for DL synchronization with downstream RS. The DL postamble sequences are generated by exclusive OR operation between DL preamble and PN sequence generated from PRBS in 8.4.9.4.1.

For the power boosting of postamble, some portion of subcarriers are substituted into PAPR reduction sequence. The MR-BS or upstream RS may broadcast the number and location of tones for PAPR reduction in DCD message for downstream RSs.

[Add parameter in table 358]

Table 359 – DCD channel encoding

Name	Type	Length	Value	Scope
Tone 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, January, 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