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Title	**GCL-based preamble design for 1024,512 and 128 FFT sizes in the OFDMA PHY layer**
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Re:	IEEE P802.16-REVe/D3-2004 Preamble Ad Hoc
Abstract	The contribution proposes to improve the scalability and performance of the ranging channel for scalable OFDMA. Ranging performance is improved by using low PAPR sequences with good cross-correlation and eliminating interference caused by initial ranging timing offsets, and a a flexible ranging resource allocation is introduced that can adjust the ranging channel resources for scalable FFT sizes.
Purpose	Adoption of proposed changes into P802.16e
Notice	
Release	
Patent Policy and Procedures	

GCL-based Preamble Design for 1024,512 and 128 FFT Sizes in the OFDMA PHY Layer

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1. Introduction

This contribution proposes preamble designs for the 1024, 512 and 128 FFT OFDMA modes. The proposed preambles have very low PAPR (lower than the preambles in IEEE C802164-04/125 in the 1024 and 512 modes). In addition, the cross correlation between any pair of the preambles is also better, allowing more reliable estimation of the channels to the desired BS, as well as the interfering BSs that are occupying the same subcarriers. The knowledge of the interference channel can be used for handover or advanced receive processing (e.g., interference suppression).

2. Basis of the Proposed Preamble

The preambles used by different sectors/cells are obtained from different "classes" of generalized chirp like (GCL) sequences [2] (unit-amplitude complex-valued sequences). The time domain waveforms of the GCL-modulated OFDM signals have low PAPR. In addition, because of the use of different "classes" of GCL sequences, any pair of the sequences will have low cross correlation at all time lags, which greatly improves the code detection and CIR estimation.

The GCL sequence is expressed as

$$s_u(k) = \exp\left\{-j2\pi u \frac{k(k+1)}{2N_G}\right\}, \quad k = 0 \cdots N_G - 1 \quad \text{and} \quad u\,(\text{"class index"}) = 1 \cdots N_G - 1 \qquad (2)$$

where N_G is the length of the GCL sequence (chosen as a prime number, explained later by Property 3) and u is referred to as the class index that is a non-zero integer chosen between 1 and N_G-1. The GCL sequence has the following important properties:

Property 1: The GCL sequence has constant amplitude, and its N_G -point DFT has also constant amplitude.

Property 2: The GCL sequences of any length have an "ideal" cyclic autocorrelation (i.e., the correlation with the circularly shifted version of itself is a delta function)

Property 3: The absolute value of the cyclic cross-correlation function between any two GCL sequences is constant and equal to $1/\sqrt{N_G}$, when $|u_1-u_2|$, u_1, and u_2 are all relatively prime to N_G (a condition that can be easily guaranteed if N_G is a prime number).

The cross-correlation $1/\sqrt{N_G}$ at all lags (Property 3) actually achieves the minimum cross-correlation value for any two sequences that have the ideal autocorrelation property (meaning that the theoretical minimum of the maximum value of the cross-correlation over all lags is achieved). The minimum is achieved when the cross correlations at all lags equal to $1/\sqrt{N_G}$. The cross correlation property allows the impact of an interfering signal be evenly spread in the time domain after correlating the received signal with the desired sequence in the time domain. Hence, at least the significant taps of the desired channel can be detected more reliably (see more in the simulation section). A simple tap-selection or "de-noising" strategy can be used to take advantage of the cross-correlation property. Tap selection simply means that the channel taps below some threshold are set to zero. Thanks to the cross correlation property, the interference channels will be evenly spread over the IFFT window after correlating with the desired preamble, so at least the significant channel tap will be estimated more reliably. Tap selection is especially effective for relatively sparse channels by attempting to match the channel estimator to the instantaneous power delay profile.

Since the desired preamble sequence length is often not an prime number, we propose to truncate from GCL sequences whose length is the smallest prime number that is larger than the desired length, or alternatively, to cyclically extend from GCL sequences whose length is the largest prime number that is smaller than the desired length. It is found that the resulting waveforms still approximate the good PAPR and cross correlation properties.

Compared with BPSK or even QPSK preambles, the complex-valued GCL sequences can be systematically constructed with guaranteed good PAPR and good correlation, although at a slightly increased price due to complex-valued division. The receive processing requirement should not be a problem in the uplink case where the base has more processing power and the PAPR is particularly appreciated by the mobile transmit device. In the downlink case, good cross correlation and low PAPR may still offset the slightly increased complexity, especially when the channel estimation is performed once in each frame. A complex-valued multiplication at each subcarrier is already needed for data detection any way and for each OFDMA symbol.

3. Proposed Text Changes

[Change paragraph in page 556 IEEE802.16d-2004. Change the table 307 to 307a]

----------------*Start from here* --

The preambles used for 1024, 512, and 128 modes are defined by

$$s_u(k) = \exp\left\{-j2\pi u \frac{k(k+1)}{2N_G}\right\}, \quad k = 0 \cdots N_G - 1 \quad \text{and} \quad u\,(\text{"}class \quad index\text{"}) = 1 \cdots N_G - 1 \qquad (2)$$

where N_G is the length of the sequence that is pre-determined according to the FFT size and u is referred to as the sequence class index that is an integer between 1 and N_G-1. The preamble, which depends on the segment used and IDcell parameter, is defined by N_G and u in Table 307b-d (PAPR comparisons are given for information only). If the specified value of N_G is larger than is needed for the sequence, then the sequence of length N_G is truncated from the end until it is the needed length.

Table 307b. 1024-point FFT

Index	ID cell	Segment	Sequence index: "u" (N_G=293)	PAPR (mean=2.99 dB)	PAPR in C802.16e-04/125 (mean=4.12 dB)
0	0	0	147	2.58	3.65
1	1	0	146	2.58	4.09
2	2	0	292	2.64	3.93
3	3	0	1	2.64	3.94
4	4	0	117	2.78	4.14
5	5	0	176	2.78	4.13
6	6	0	220	2.9	4
7	7	0	73	2.9	4.01
8	8	0	49	2.95	4.1
9	9	0	244	2.95	4.02
10	10	0	98	3.11	4.05
11	11	0	195	3.11	3.98
12	12	0	42	3.12	4.05
13	13	0	251	3.12	4.14
14	14	0	205	3.17	4.08
15	15	0	88	3.17	4.2
16	16	0	45	3.19	4
17	17	0	248	3.19	4.2
18	18	0	185	3.2	4.15
19	19	0	108	3.2	4.26
20	20	0	224	3.22	4.25
21	21	0	69	3.22	4.11
22	22	0	179	3.25	4.17
23	23	0	114	3.25	3.96
24	24	0	21	3.26	4.12
25	25	0	272	3.26	4.27
26	26	0	228	3.27	4.26
27	27	0	65	3.27	4.04
28	28	0	149	3.33	4.25
29	29	0	144	3.33	4.14
30	30	0	39	3.33	4.2
31	31	0	254	3.33	4.26
32	0	1	292	2.31	3.96

33	1	1	1	2.31	3.96
34	2	1	146	2.41	3.97
35	3	1	147	2.41	3.97
36	4	1	73	2.63	3.97
37	5	1	220	2.63	3.98
38	6	1	49	2.71	3.98
39	7	1	244	2.71	3.99
40	8	1	42	2.77	3.99
41	9	1	251	2.77	3.99
42	10	1	117	2.77	3.99
43	11	1	176	2.77	3.99
44	12	1	98	2.83	3.99
45	13	1	195	2.83	4
46	14	1	179	2.88	4
47	15	1	114	2.88	4
48	16	1	185	2.99	4
49	17	1	108	2.99	4.01
50	18	1	248	3	4.01
51	19	1	45	3	4.01
52	20	1	224	3	4.02
53	21	1	69	3	4.02
54	22	1	40	3.03	4.02
55	23	1	253	3.03	4.02
56	24	1	272	3.04	4.02
57	25	1	21	3.04	4.02
58	26	1	39	3.05	4.02
59	27	1	254	3.05	4.02
60	28	1	238	3.06	4.03
61	29	1	55	3.06	4.03
62	30	1	110	3.14	4.03
63	31	1	183	3.14	4.03
64	0	2	292	2.28	4.27
65	1	2	1	2.28	4.36
66	2	2	73	2.51	4.35
67	3	2	220	2.51	4.29

68	4	2	98	2.58	4.37
69	5	2	195	2.58	4.2
70	6	2	146	2.63	4.35
71	7	2	147	2.63	4.37
72	8	2	42	2.84	4.21
73	9	2	251	2.84	4.12
74	10	2	244	2.85	4.11
75	11	2	49	2.85	4.23
76	12	2	183	2.86	4.06
77	13	2	110	2.86	4.19
78	14	2	117	2.94	4.12
79	15	2	176	2.94	4.18
80	16	2	39	2.98	4.22
81	17	2	254	2.98	4.15
82	18	2	21	3.03	4.19
83	19	2	272	3.03	4.17
84	20	2	253	3.06	4.14
85	21	2	40	3.06	4.24
86	22	2	179	3.06	4.21
87	23	2	114	3.06	4.29
88	24	2	69	3.07	4.27
89	25	2	224	3.07	4.31
90	26	2	228	3.12	4.25
91	27	2	65	3.12	4.29
92	28	2	157	3.2	4.13
93	29	2	136	3.2	4.23
94	30	2	51	3.21	4.15
95	31	2	242	3.21	4.15
96	0	0	83	3.34	4.26
97	1	1	171	3.17	4.03
98	2	2	55	3.22	4.2
99	3	0	210	3.34	4.1
100	4	1	122	3.17	4.04
101	5	2	238	3.22	4.25
102	6	0	122	3.35	4.22

103	7	1	65	3.18	4.05
104	8	2	82	3.23	4.2
105	9	0	171	3.35	4.28
106	10	1	228	3.18	4.05
107	11	2	211	3.23	4.35
108	12	0	238	3.35	4.37
109	13	1	205	3.22	4.06
110	14	2	83	3.26	4.35
111	15	0	55	3.35	4.13
112	16	1	88	3.22	4.06
113	17	2	210	3.26	4.23

Table 307c. 512-point FFT

Index	ID cell	Segment	Sequence index: "u" (N_G=149)	PAPR (mean=3.18 dB)	PAPR in C802.16e-04/125 (mean=3.60 dB)
0	0	0	74	2.59	3.83
1	1	0	75	2.59	3.65
2	2	0	112	2.83	3.79
3	3	0	37	2.83	3.63
4	4	0	1	2.88	3.63
5	5	0	148	2.88	3.83
6	6	0	99	2.97	3.83
7	7	0	50	2.97	3.58
8	8	0	25	3.18	3.85
9	9	0	124	3.18	3.84
10	10	0	30	3.25	3.91
11	11	0	119	3.25	3.49
12	12	0	27	3.28	3.83
13	13	0	122	3.28	3.76
14	14	0	23	3.31	3.83
15	15	0	126	3.31	3.88
16	16	0	121	3.34	3.75
17	17	0	28	3.34	3.88
18	18	0	47	3.42	3.85

19	19	0	102	3.42	3.6
20	20	0	15	3.45	3.83
21	21	0	134	3.45	3.79
22	22	0	78	3.5	3.7
23	23	0	71	3.5	3.49
24	24	0	117	3.5	3.81
25	25	0	32	3.5	3.67
26	26	0	58	3.51	3.67
27	27	0	91	3.51	3.88
28	28	0	24	3.52	3.9
29	29	0	125	3.52	3.86
30	30	0	82	3.55	3.55
31	31	0	67	3.55	3.83
32	0	1	74	2.3	3.46
33	1	1	75	2.3	3.46
34	2	1	148	2.34	3.46
35	3	1	1	2.34	3.46
36	4	1	37	2.71	3.46
37	5	1	112	2.71	3.46
38	6	1	50	2.78	3.46
39	7	1	99	2.78	3.46
40	8	1	119	2.92	3.46
41	9	1	30	2.92	3.46
42	10	1	23	2.98	3.46
43	11	1	126	2.98	3.46
44	12	1	124	3.04	3.47
45	13	1	25	3.04	3.47
46	14	1	15	3.04	3.47
47	15	1	134	3.04	3.47
48	16	1	35	3.2	3.47
49	17	1	114	3.2	3.47
50	18	1	27	3.25	3.48
51	19	1	122	3.25	3.48
52	20	1	10	3.27	3.48
53	21	1	139	3.27	3.48

54	22	1	82	3.31	3.49
55	23	1	67	3.31	3.49
56	24	1	58	3.35	3.49
57	25	1	91	3.35	3.49
58	26	1	117	3.36	3.49
59	27	1	32	3.36	3.5
60	28	1	36	3.41	3.5
61	29	1	113	3.41	3.5
62	30	1	33	3.42	3.5
63	31	1	116	3.42	3.5
64	0	2	74	2.3	3.5
65	1	2	75	2.3	3.5
66	2	2	148	2.34	3.5
67	3	2	1	2.34	3.5
68	4	2	37	2.71	3.5
69	5	2	112	2.71	3.51
70	6	2	50	2.78	3.51
71	7	2	99	2.78	3.51
72	8	2	119	2.92	3.51
73	9	2	30	2.92	3.51
74	10	2	23	2.98	3.51
75	11	2	126	2.98	3.51
76	12	2	124	3.04	3.51
77	13	2	25	3.04	3.51
78	14	2	15	3.04	3.51
79	15	2	134	3.04	3.52
80	16	2	35	3.2	3.52
81	17	2	114	3.2	3.52
82	18	2	27	3.25	3.52
83	19	2	122	3.25	3.53
84	20	2	10	3.27	3.53
85	21	2	139	3.27	3.53
86	22	2	82	3.31	3.54
87	23	2	67	3.31	3.54
88	24	2	58	3.35	3.54

89	25	2	91	3.35	3.54
90	26	2	117	3.36	3.54
91	27	2	32	3.36	3.54
92	28	2	36	3.41	3.54
93	29	2	113	3.41	3.54
94	30	2	33	3.42	3.54
95	31	2	116	3.42	3.54
96	0	0	56	3.57	3.9
97	1	1	71	3.48	3.54
98	2	2	71	3.48	3.54
99	3	0	93	3.57	4.01
100	4	1	78	3.48	3.54
101	5	2	78	3.48	3.54
102	6	0	10	3.58	3.93
103	7	1	102	3.53	3.54
104	8	2	102	3.53	3.54
105	9	0	139	3.58	3.85
106	10	1	47	3.53	3.54
107	11	2	47	3.53	3.54
108	12	0	135	3.61	3.98
109	13	1	125	3.56	3.55
110	14	2	125	3.56	3.55
111	15	0	14	3.61	4
112	16	1	24	3.56	3.55
113	17	2	24	3.56	3.55

Table 307d. 128-point FFT

Index	ID cell	Segment	Sequence index: "u" (N_G=41)	PAPR (mean=4.23 dB)	PAPR in C802.16e-04/125 (mean=3.22 dB)
0	0	0	40	2.74	2.24
1	1	0	1	2.74	2.27
2	2	0	20	2.74	2.31
3	3	0	21	2.74	2.32
4	4	0	14	3.16	2.35

5	5	0	27	3.16	2.38
6	6	0	7	3.24	2.38
7	7	0	34	3.24	2.39
8	8	0	10	3.3	2.41
9	9	0	31	3.3	2.42
10	10	0	9	3.56	2.42
11	11	0	32	3.56	2.42
12	12	0	6	3.6	2.42
13	13	0	35	3.6	2.42
14	14	0	24	3.94	2.43
15	15	0	17	3.94	2.44
16	16	0	8	4.03	2.44
17	17	0	33	4.03	2.45
18	18	0	15	4.13	2.47
19	19	0	26	4.13	2.48
20	20	0	39	4.2	2.49
21	21	0	2	4.2	2.49
22	22	0	37	4.45	2.49
23	23	0	4	4.45	2.49
24	24	0	5	4.47	2.5
25	25	0	36	4.47	2.5
26	26	0	23	4.7	2.5
27	27	0	18	4.7	2.5
28	28	0	38	5.02	2.5
29	29	0	3	5.02	2.5
30	30	0	12	5.02	2.5
31	31	0	29	5.02	2.5
32	0	1	1	2.76	3.64
33	1	1	40	2.76	3.64
34	2	1	10	3.14	3.64
35	3	1	31	3.14	3.42
36	4	1	20	3.59	3.64
37	5	1	21	3.59	3.64
38	6	1	7	3.68	3.19
39	7	1	34	3.68	3.35

40	8	1	14	3.71	3.25
41	9	1	27	3.71	3.64
42	10	1	6	3.81	3.64
43	11	1	35	3.81	3.64
44	12	1	33	3.82	3.64
45	13	1	8	3.82	3.64
46	14	1	37	4.21	3.14
47	15	1	4	4.21	3.29
48	16	1	18	4.3	3.19
49	17	1	23	4.3	3.35
50	18	1	32	4.32	3.64
51	19	1	9	4.32	3.64
52	20	1	24	4.37	3.64
53	21	1	17	4.37	3.64
54	22	1	36	4.45	3.62
55	23	1	5	4.45	2.7
56	24	1	29	4.51	3.34
57	25	1	12	4.51	3.64
58	26	1	26	4.59	3.32
59	27	1	15	4.59	3.64
60	28	1	2	4.6	3.39
61	29	1	39	4.6	3.48
62	30	1	38	4.77	3.6
63	31	1	3	4.77	3.37
64	0	2	33	3.23	4.13
65	1	2	8	3.23	3.56
66	2	2	6	3.38	4.19
67	3	2	35	3.38	4.19
68	4	2	4	3.7	3.93
69	5	2	37	3.7	4.69
70	6	2	9	3.77	2.75
71	7	2	32	3.77	2.75
72	8	2	40	3.87	3.41
73	9	2	1	3.87	3.86
74	10	2	7	4.01	3.86

75	11	2	34	4.01	3.56
76	12	2	14	4.12	3.25
77	13	2	27	4.12	4.08
78	14	2	10	4.2	3.79
79	15	2	31	4.2	3.44
80	16	2	26	4.27	3.56
81	17	2	15	4.27	3.25
82	18	2	22	4.34	3.19
83	19	2	19	4.34	3.3
84	20	2	20	4.61	3.3
85	21	2	21	4.61	3.3
86	22	2	11	4.75	4.69
87	23	2	30	4.75	4.14
88	24	2	5	4.8	3.34
89	25	2	36	4.8	3.53
90	26	2	17	4.8	3.5
91	27	2	24	4.8	4.69
92	28	2	38	4.97	3.88
93	29	2	3	4.97	4.1
94	30	2	23	4.98	3.47
95	31	2	18	4.98	3.86
96	0	0	22	5.2	2.56
97	1	1	19	4.79	3.22
98	2	2	29	4.98	3.93
99	3	0	19	5.2	2.57
100	4	1	22	4.79	3.57
101	5	2	12	4.98	4.69
102	6	0	28	5.21	2.57
103	7	1	11	4.83	3.52
104	8	2	2	5.36	4.01
105	9	0	13	5.21	2.57
106	10	1	30	4.83	3.41
107	11	2	39	5.36	4.03
108	12	0	30	5.48	2.57
109	13	1	16	5.01	3.64

110	14	2	16	5.75	4.02
111	15	0	11	5.48	2.58
112	16	1	25	5.01	2.86
113	17	2	25	5.75	3.46

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4. Additional Information

In addition to the low PAPR properties, the cross correlation properties of the proposed preambles are much better than PN-based BPSK sequences such as those proposed in IEEE C80216e-04/125, as can be seen in the following Figure 1-3 where the cross correlation of all pairs of preambles that are used for segment 0 is plotted (similar correlation for segment 1 and 2). In IEEE C80216e-04/125, there are a few sequences used twice for segment 0, but for different cellIDs (e.g., for the 512 mode and for segment 1, preamble #1 = preamble #2, #8 = #9, #12 = #13, #15 = #16; for the 128 mode and for segment 2, preamble #1 = preamble #2, #6 = preamble #16, and there are more. But the problem only occurs for 512 and 128 modes). We believe there may be some errors in IEEE C80216e-04/125, and these cross correlation are already excluded from the plot.

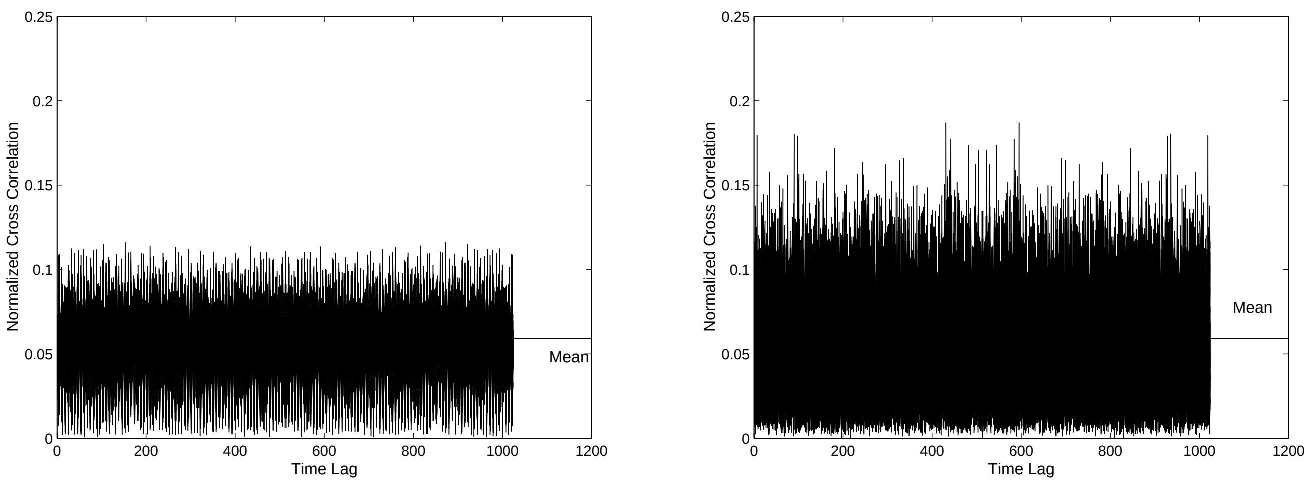

Figure 1. Cross- correlation characteristics of the proposed preamble (left) and the BPSK PN ranging sequence (right) from IEEE C80216e-04/125 (1024 mode)

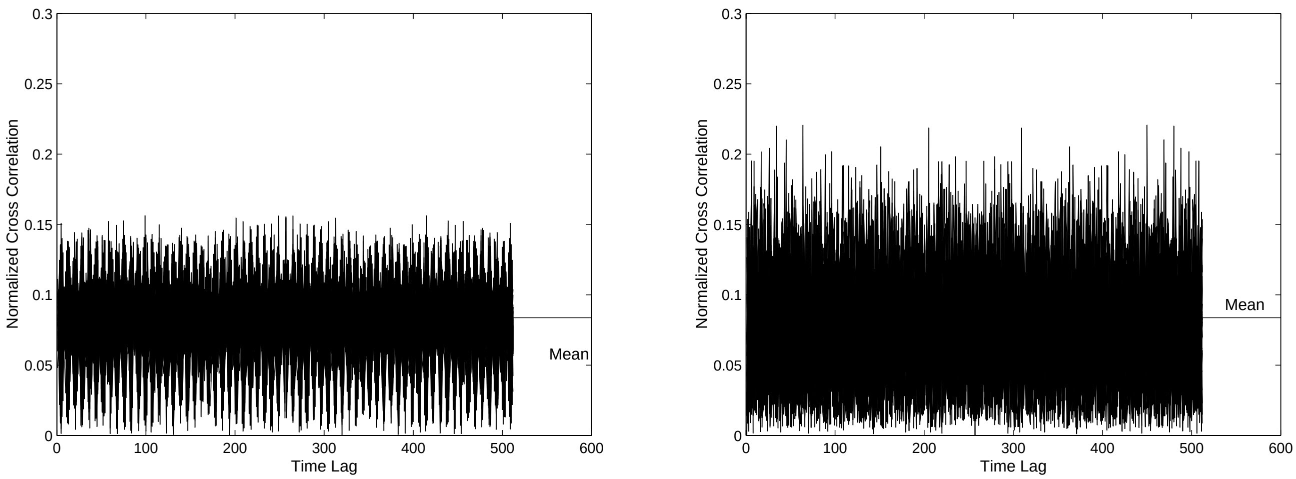

Figure 2. Cross- correlation characteristics of the proposed preamble (left) and the BPSK PN ranging sequence (right) from IEEE C80216e-04/125 (512 mode)

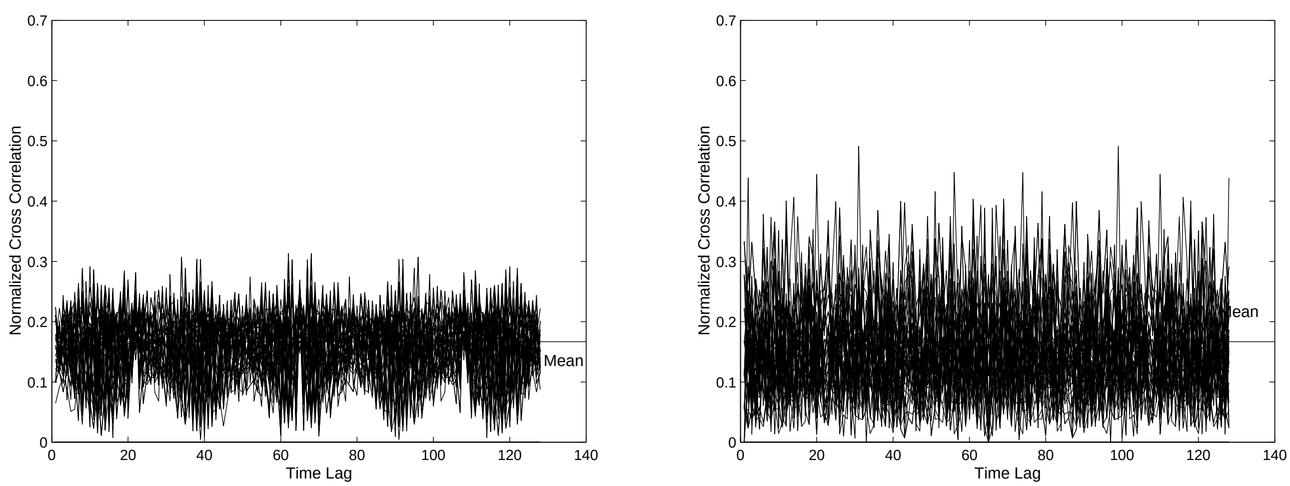

Figure 3. Cross- correlation characteristics of the proposed preamble (left) and the BPSK PN ranging sequence (right) from IEEE C80216e-04/125 (128 mode)

This cross advantage translates into improved channel estimation performance, as can be seen in the following figure, especially for low SINR (but with decent SNR, which is 7dB in the figure). Two base stations are simulated in the figure (one desired and one interfering). The comparison is made between GCL design and random BPSK design in which a random BPSK sequence is used in each Monte Carlo trial (similar overall cross correlation to that for sequences in IEEE C80216e-04/125). As we can see that even for very low SINR, the channel estimation performance is still reasonable, especially when the delay spread is relatively small. If this SINR is rather for the interference signal, it means that the channel to the weaker interference base station can be monitored reasonably well (which is good for hard- or soft- handover, potential interference suppression, BS-cooperative scheduling, etc.).

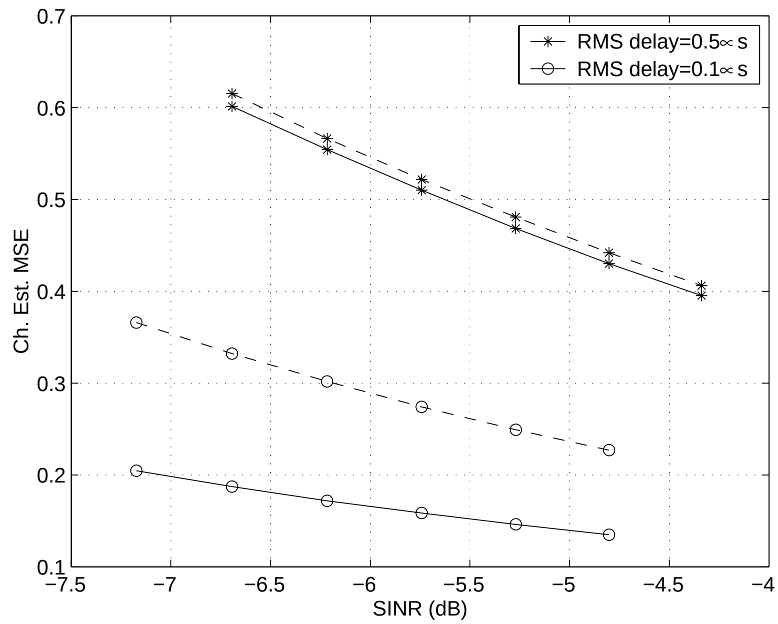

Figure 3. Channel estimation error under different delay spread with proposed design (solid lines) and a random BPSK preamble design (dashed lines) for the1024 mode.

In fact, we can see from the 1024, 512, and 128 modes that the longer the GCL sequence, the better the cross correlation and the easier to choose a subset of sequences with very good PAPR. In addition, the approximation due to truncation can also be made nearly negligible if the sequence is long. Although the 2048 mode is not under the scope of the proposed change, but just to show how easy and effective the GCL-based preamble design can be, we show in the below a quick design for the 2048 mode and an average 1.4dB PAPR reduction is obtained with additional benefit of good cross correlation.

Table YYYa. 2048-point FFT (just to show the easiness and effectiveness of GCL design)

Index	ID cell	Segment	Sequence index: "u" (N_G=569)	PAPR (mean=2.91 dB)	PAPR in C802.16e-04/125 (mean=4.62 dB)
0	0	0	1	2.75	4.34
1	1	0	568	2.75	4.29
2	2	0	190	2.75	4.31
3	3	0	379	2.75	4.49
4	4	0	284	2.8	4.39
5	5	0	285	2.8	4.53
6	6	0	95	2.84	4.4

7	7	0	474	2.84	4.49
8	8	0	427	2.86	4.56
9	9	0	142	2.86	4.39
10	10	0	71	2.87	4.52
11	11	0	498	2.87	4.44
12	12	0	114	2.97	4.58
13	13	0	455	2.97	4.47
14	14	0	512	3	4.46
15	15	0	57	3	4.59
16	16	0	244	3.03	4.48
17	17	0	325	3.03	4.54
18	18	0	253	3.03	4.6
19	19	0	316	3.03	4.5
20	20	0	38	3.03	4.6
21	21	0	531	3.03	4.58
22	22	0	394	3.04	4.6
23	23	0	175	3.04	4.44
24	24	0	539	3.1	4.63
25	25	0	30	3.1	4.59
26	26	0	561	3.11	4.49
27	27	0	8	3.11	4.53
28	28	0	362	3.12	4.63
29	29	0	207	3.12	4.65
30	30	0	271	3.12	4.65
31	31	0	298	3.12	4.63
32	0	1	1	2.54	4.45
33	1	1	568	2.54	4.46
34	2	1	284	2.56	4.46
35	3	1	285	2.56	4.46
36	4	1	190	2.63	4.46
37	5	1	379	2.63	4.47
38	6	1	427	2.64	4.48
39	7	1	142	2.64	4.49
40	8	1	455	2.71	4.5
41	9	1	114	2.71	4.5

42	10	1	95	2.71	4.5
43	11	1	474	2.71	4.5
44	12	1	498	2.76	4.51
45	13	1	71	2.76	4.51
46	14	1	531	2.8	4.51
47	15	1	38	2.8	4.51
48	16	1	512	2.84	4.52
49	17	1	57	2.84	4.52
50	18	1	253	2.87	4.52
51	19	1	316	2.87	4.52
52	20	1	325	2.89	4.52
53	21	1	244	2.89	4.52
54	22	1	30	3.01	4.53
55	23	1	539	3.01	4.54
56	24	1	175	3.03	4.54
57	25	1	394	3.03	4.54
58	26	1	207	3.06	4.55
59	27	1	362	3.06	4.55
60	28	1	388	3.11	4.55
61	29	1	181	3.11	4.55
62	30	1	274	3.12	4.55
63	31	1	295	3.12	4.55
64	0	2	1	2.5	4.63
65	1	2	568	2.5	4.69
66	2	2	427	2.51	4.71
67	3	2	142	2.51	4.74
68	4	2	71	2.65	4.79
69	5	2	498	2.65	4.68
70	6	2	379	2.67	4.78
71	7	2	190	2.67	4.47
72	8	2	455	2.67	4.74
73	9	2	114	2.67	4.7
74	10	2	284	2.72	4.79
75	11	2	285	2.72	4.63
76	12	2	95	2.74	4.67

77	13	2	474	2.74	4.77
78	14	2	325	2.84	4.72
79	15	2	244	2.84	4.7
80	16	2	175	2.86	4.61
81	17	2	394	2.86	4.71
82	18	2	30	2.86	4.83
83	19	2	539	2.86	4.83
84	20	2	57	2.87	4.76
85	21	2	512	2.87	4.81
86	22	2	316	2.9	4.85
87	23	2	253	2.9	4.83
88	24	2	531	2.91	4.85
89	25	2	38	2.91	4.71
90	26	2	207	2.95	4.78
91	27	2	362	2.95	4.77
92	28	2	19	2.98	4.84
93	29	2	550	2.98	4.83
94	30	2	91	3.07	4.84
95	31	2	478	3.07	4.82
96	0	0	388	3.21	4.84
97	1	1	298	3.15	4.66
98	2	2	388	3.11	4.82
99	3	0	181	3.21	4.87
100	4	1	271	3.15	4.69
101	5	2	181	3.11	4.87
102	6	0	19	3.22	4.91
103	7	1	564	3.16	4.71
104	8	2	332	3.11	4.88
105	9	0	550	3.22	4.87
106	10	1	5	3.16	4.71
107	11	2	237	3.11	4.85
108	12	0	194	3.27	4.75
109	13	1	550	3.17	4.74
110	14	2	5	3.13	4.88
111	15	0	375	3.27	4.82

112	16	1	19	3.17	4.75
113	17	2	564	3.13	4.94

5. References:

[1] Yossi Segal, “Preambles design for OFDMA PHY layer, FFT sizes of 1024,512 and 128,” IEEE C802.16e-04/125, June 2004

[2] B.M. Popovic, “Generalized Chirp-like Polyphase Sequences with Optimal Correlation Properties,” IEEE Trans. Info. Theory, vol. 38, pp. 1406-1409, July 1992