Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Larger CTC block sizes for OFDMA**
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Re:	IEEE P802.16e/D5-2004
Abstract	Optimized interleaver parameters for CTCs (Convolutional Turbo Codes) are given to support a larger range of block sizes for OFDMA subchannelization
Purpose	To incorporate the given tables, with accompanying text, in this contribution into IEEE 802.16e/D5-2004
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Release	

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Larger CTC block sizes for OFDMA

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Motivation

The concatenation/fragmentation scheme for CTC blocks is currently limited to a maximum of 60 byte data blocks. Fragmenting large packets into many small blocks yield sub-optimal performance. The performance is affected adversely in two ways. First, performance gain from FEC codes decreases with smaller block sizes. Second, fewer (larger sized) blocks will have a better chance of successful transmission than more (smaller sized) blocks.

A new concatenation rule for CTC blocks is proposed here. The new rule increases the sizes of the fragmented blocks in the OFDMA channel. In order to avoid backward compatibility issues with the concatenation defined in 802.16d, this proposal will suggest an extended (optional) scheme that will supplement the old block sizes and subchannelization.

With the current standard, the only way to see the performance gains with higher block sized CTCs is to use the *optional* H-ARQ mode. Optimized code performance (by increasing block size) should not be limited to H-ARQ, especially when it is straightforward to implement. Assuming a decoder is available to handle 600 byte data packets (max block size of H-ARQ), the added complexity to the original CTC implementation is negligible, when increasing the number of possible block-sizes. To implement this *only* requires the additional storage of the new P0, P1, P2, P3 parameters. This will ensure maximum performance gain with the larger block sizes. In addition to the new large block sizes, a modification to the concatenation rules is also proposed.

Proposed Solution

In this proposal the maximum block size, which was previously only 60 information bytes in non H-ARQ mode, will be increased to a maximum of 240 information bytes. This corresponds to an increase in subchannel slots used in QPSK from 10 to up to 40, and in 64QAM from 3 up to 12. Outer interleaver parameters for the new block sizes are also defined in Table 327a.

Performance

In order for packets to be received correctly, all block fragments must be received without error. A direct result of increasing the block sizes is a decrease in the number of fragmented blocks needed to be sent. Due to the concatenation scheme, the error rate performance of a burst is dependent on the number of FEC blocks and the size of each block. The concatenation ensures the minimum length of the last two FEC blocks to be at least half of the maximum FEC block length. This results in the concatenation of a large packet into a number of max FEC block sizes plus 2 blocks of FEC size at least _ of the max FEC block length.

Below two examples are given:

QPSK, Rate = _, 576 byte and 1500 byte MTU packets, yielding 96 and 250 sub-channels respectively.

Concatenation Scheme	**J** (QPSK, R=1/2)	**# Blocks** 576 bytes	**Coded Blocks(bytes)** 576 byte data packet	**# Blocks** 1500 byte	**Coded Blocks (bytes)** 1500 byte data packet
Current	10	**10**	8*120, 2*96	**26**	24*120, 2*60
Proposed	40	**3**	1*480, 1*348, 1*324	**7**	5*480, 2*300

In the case of a 1500 byte MTU packet, the proposed scheme will reduce the number of transmitted block from 26 to 7. This will result in a significant decrease in PER. The first figure depicts the performance obtained with the CTC blocksizes involved in the 1500-byte MTU packet example (current and new concatenation scheme) and show the gains when larger blocksizes are employed. The second figure shows the potential performance improvement with the new concatenation scheme.

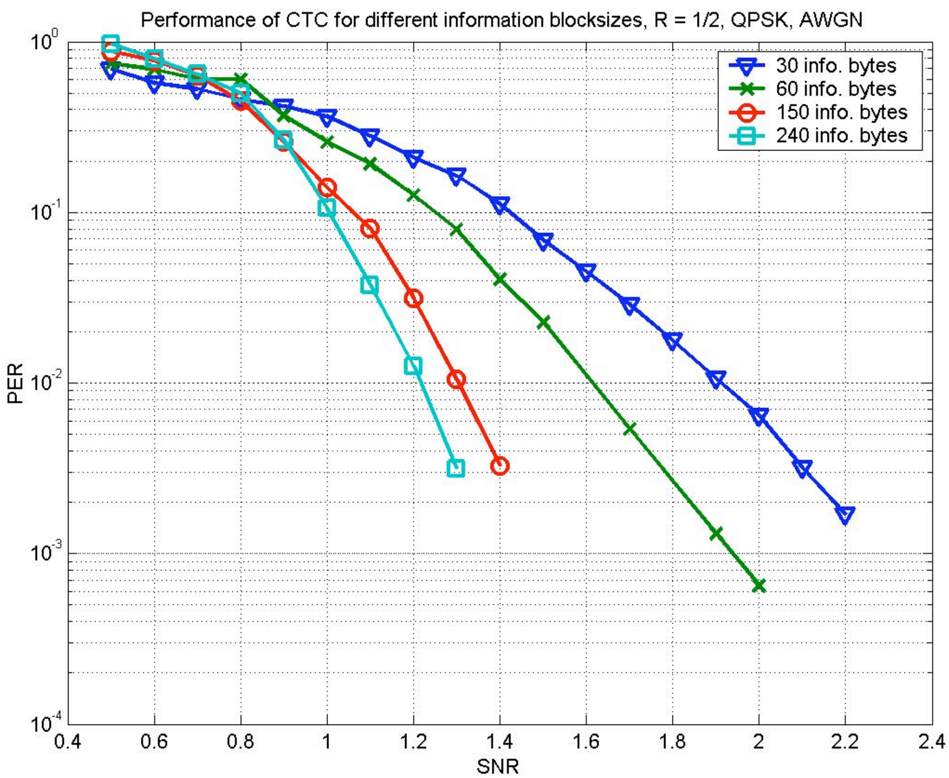

Figure 1 – Performance of CTC for different blocksizes (1500-byte MTU packet example)

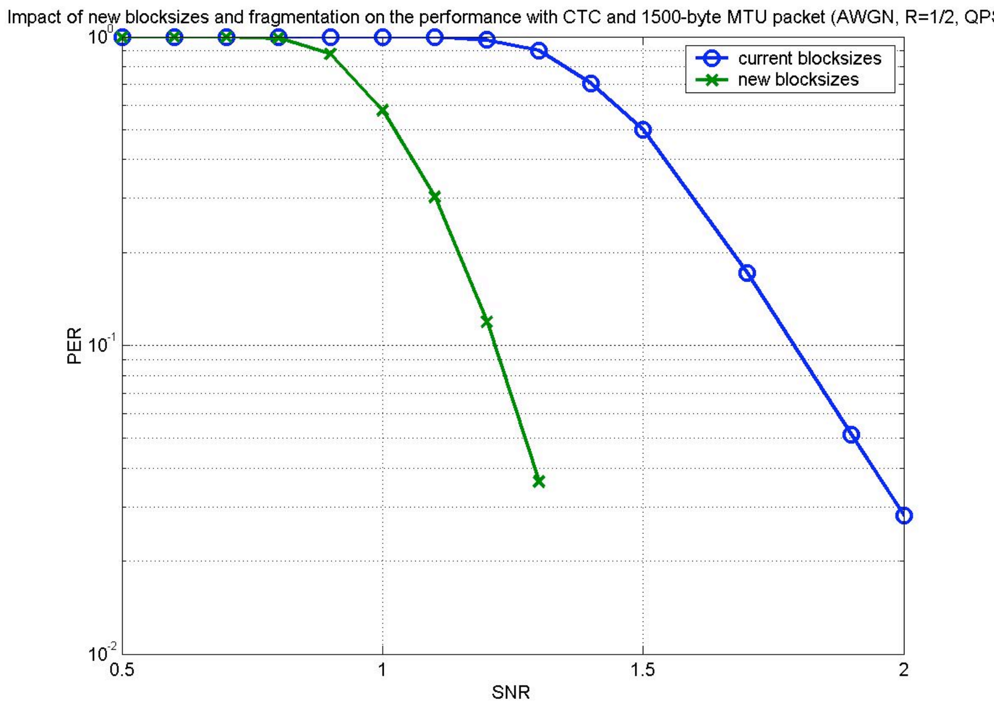

Figure 2 – Performance comparison of the current concatenation scheme and the proposed solution

Suggestion: To add Tables 322a, 323a, and 324a (increasing number of blocks), to Section 8.4.9.2.3.1, and Table 327a to Section 8.4.9.2.3.4.2 with the following text.

1.MAC Modifications

This section will include the necessary modifications in the MAC to signal the CTC block extension mode.

2.Section 8.4.9.2.3.1

Recommended Text Changes:

Make the following changes to IEEE 802.16e/D6 (February 2005), adjusting the numbering as required.

<Insert the following text on p. 232, line 46.>

In Table 268 and 268b, CTC refers to the basic CTC, not the large-block-size CTC.

<Insert the following section heading, text, and table on p. 443 line 63.>

8.4.9.2.3.1 CTC encoder

[Insert text after table 327 "Optimal CTC channel coding per modulation when supporting H-ARQ"]

<ADDED TEXT> For large-block-size CTC where the information block size are extended to 240 bytes, Table 3244a, 3255a, 3266a are used instead of Table 324, 325, 326. A new Table 3244a defines the subchannel concatenation scheme rule; Table 3255a defines the encoding subchannel concatenation parameter *j* for different modulation and coding rates; of the CTC blocks is defined to allow frame sizes up to 240 bytes. The rules to be used with the new concatenation scheme are defined fully in Tables 322a and 323a. Table 32466a specifies optimized interleaver parameters for data block frame sizes (unencoded blocks) between 6-240 bytes. Similar to the basic CTC, theThis is large-block-size CTC is used for OFDMA subchannelization with QPSK, 16-QAM and 64-QAM. When a SS supports large-block-size CTC, the large block size will be used for all unicast messages to and from that SS when a CTC encoding is specified in the DIUC. All broadcast messages and multicast messages will use the basic CTC to insure backwards compatibility.

Table 32224a – Subchannel concatenation rule for large-block-size CTC

Number of Subchannels	**Subchannels concatenated**
n ≤= j AND n mod 7 ≠ 0	1 block of n slots
n<=j AND n mod 7 = 0	1 block of 4n/7 slots 1 block of 3n/7 slots

n > j	If(n mod j = 0)
	k blocks of j slots
	else
	(k-1) blocks of j slots
	1 block of L_{b1} slots
	1 block of L_{b2} slots
	Where:
	L_{b1} = ceil((m+j)/2)
	L_{b2} = floor((m+j)/2)
	If (L_{b1} mod 7= 0) or (L_{b2} mod 7= 0)
	$L_{b1} = L_{b1} + 1$; $L_{b2} = L_{b2} - 1$;

Table 3235a – Encoding subchannel concatenation for different rates in large-block-size CTC

Modulation and rate	J
QPSK 1/2	j = 40
QPSK 3/4	j = 26
QAM16 1/2	j = 20
QAM16 3/4	j = 13
QAM64 1/2	j = 13
QAM64 2/3	j = 10
QAM64 3/4	j = 8
QAM64 5/6	j = 8

Table 3246a – Large-block-size CTC channel coding for additional OFDMA Block Sizes

Data	Encoded data block size (bytes)	N	P0	P1	P2	P3

	QPSK		16QAM		64QAM								
	1/2	3/4	1/2	3/4	1/2	2/3	3/4	5/6					
6	12	-	-	-	-	-	-	-	24	5	0	0	0
9	-	12	-	-	-	-	-	-	36	11	18	0	18
12	24	-	24	-	-	-	-	-	48	13	24	0	24
18	36	24	-	24	36	-	-	-	72	11	6	0	6
24	48	-	48	-	-	36	-	-	96	7	48	24	72
27	-	36	-	-	-	-	36	-	108	11	54	56	2
30	60	-	-	-	-	-	-	36	120	13	60	0	60
36	72	48	72	48	72	-	-	-	144	17	74	72	2
45	-	60	-	-	-	-	-	-	180	11	90	0	90
48	96	-	96	-	-	72	-	-	192	11	96	48	144
54	108	72	-	72	108	-	72	-	216	13	108	0	108
60	120	-	120	-	-	-	-	72	240	13	120	60	180
66	132	-	-	-	-	-	-	-	264	23	2	160	30
72	144	96	144	96	144	108	-	-	288	23	50	188	50
78	156	-	-	-	-	-	-	-	312	23	102	64	38
81	-	108	-	-	-	-	108	-	324	11	172	164	16
90	180	120	-	120	180	-	-	108	360	29	56	0	68
96	192	-	192	-	-	144	-	-	384	29	68	140	56
99	-	132	-	-	-	-	-	-	396	29	36	128	76
102	204	-	-	-	-	-	-	-	408	29	124	204	40
108	216	144	216	144	216	-	144	-	432	13	0	4	8
114	228	-	-	-	-	-	-	-	456	31	100	224	104
117	-	156	-	-	-	-	-	-	468	31	98	220	98
120	240	-	240	-	-	180	-	144	480	31	52	240	52
132	264	-	264	-	-	-	-	-	528	31	24	36	104
135	-	180	-	-	-	-	180	-	540	31	42	248	34
138	276	-	-	-	-	-	-	-	552	35	14	136	6
144	288	192	288	192	288	216	-	-	576	31	42	232	18
150	300	-	-	-	-	-	-	180	600	37	20	152	0
153	-	204	-	-	-	-	-	-	612	37	6	164	14
156	312	-	312	-	-	-	-	-	624	37	312	156	468
162	324	216	-	216	324	-	216	-	648	37	62	160	34
171	-	228	-	-	-	-	-	-	684	37	108	136	8
174	348	-	-	-	-	-	-	-	696	37	0	128	12
180	360	240	360	240	360	-	-	216	720	37	92	100	68
186	372	-	-	-	-	-	-	-	744	37	54	196	50

192	384	-	384	-	-	288	-	-	768	19	384	216	600
198	396	264	-	264	396	-	-	-	792	41	0	228	24
204	408	-	408	-	-	-	-	-	816	37	408	204	612
207	-	276	-	-	-	-	-	-	828	41	136	288	192
216	432	288	432	288	432	324	288	-	864	19	2	16	6
222	444	-	-	-	-	-	-	-	888	43	10	220	18
225	-	300	-	-	-	-	-	-	900	43	8	56	20
228	456	-	456	-	-	-	-	-	912	43	96	8	124
234	468	312	-	312	468	-	-	-	936	43	120	140	124
240	480	-	480	-	-	360	-	288	960	43	52	120	28

8.4.9.2.3.4.2 Subblock interleaving

[Insert text before Table 329 "Parameters for the subblock interleavers"]

For large-block-size CTC, Table 329a should be used to provide subblock interleaver parameters for additional block sizes.

[Insert Table 329a after Table 329 "Parameters for the subblock interleavers"]

~~3.Section 8.4.9.2.3.4.2 Subblock interleaving~~

~~<ADDED TEXT> Table 327a (along with Table 327) gives subblock interleaver parameters for the new CTC sub-channelization defined by Tables 322a, 323a, 324a.~~

Table 32~~7~~9a – Parameters for subblock interleavers for large-block-size CTC

Block size (bits) NEP	N	Subblock Interleaver Parameters		Block size (bits) NEP	N	Subblock Interleaver Parameters	
		m	J			m	J
48	24	3	3	960	480	8	2
72	36	4	3	1056	528	8	3
96	48	4	3	1080	540	8	3
144	72	5	3	1104	552	8	3
192	96	5	3	1152	576	8	3
216	108	6	3	1200	600	8	3
240	120	6	2	1224	612	8	3
288	144	6	3	1248	624	8	3
360	180	6	3	1296	648	8	3
384	192	6	3	1368	684	8	3
432	216	6	4	1392	696	8	3
480	240	7	2	1440	720	8	3
528	264	7	3	1488	744	8	3
576	288	7	3	1536	768	8	4
624	312	7	3	1584	792	8	4
648	324	7	3	1632	816	8	4
720	360	7	3	1656	828	8	4
768	384	7	3	1728	864	8	4
792	396	7	4	1776	888	8	4
816	408	7	4	1800	900	8	4
864	432	7	4	1824	912	8	4
912	456	8	2	1872	936	8	4

936	468	8	2	1920	960	9	2

<Revise the table in section 11.8.3.7.2, "OFDMA MS demodulator", as follows. Underlined text is new.>

Type	Length	Value	Scope
151	variable	Bit #0: 64-QAM Bit #1: BTC Bit #2: CTC Bit #3: STC Bit #4: AAS Diversity Map Scan Bit #5: HARQ Chase Bit #6: HARQ CTC_IR Bit #7: HARQ with SPID=0 only Bit #8: HARQ CC IR Bit #9: LDPC Bit #10: Large-block-size CTC Bits #~~10~~11-15: *Reserved*; shall be set to zero.	SBC-REQ (see 6.3.2.3.23) SBC-RSP (see 6.3.2.3.24)

<Revise the table in section 11.8.3.7.3, OFDMA MS modulator, as follows. Underlined text is new.>

Type	Length	Value	Scope
152	variable	Bit #0: 64-QAM Bit #1: BTC Bit #2: CTC Bit #3: STC Bit #4: AAS Diversity Map Scan Bit #5: HARQ Chase Bit #6: HARQ CTC IR Bit #7: HARQ with SPID=0 only. Bit #8: HARQ CC IR Bit #9: LDPC Bit #10: Large-block-size CTC Bits #~~10~~11-15: *Reserved*; shall be set to zero.	SBC-REQ (see 6.3.2.3.23) SBC-RSP (see 6.3.2.3.24)
153	1	The number of HARQ ACK Channel	SBC-REQ (see 6.3.2.3.23) SBC-RSP (see 6.3.2.3.24)