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	The current CTC (non-IR) supports only up to 60-byte payloads, at least an order of magnitude smaller than most turbo coded systems. CTC parameters are given to support a larger range of block sizes for OFDMA subchannelization. The use of the larger block sizes is negotiated.
Purpose	To incorporate the given tables, with accompanying text, in this contribution into IEEE 802.16e/D5-2004
Notice	
Release	
Patent Policy and Procedures	

Larger CTC block sizes for OFDMA

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Motivation

The concatenation/fragmentation scheme for CTC (Convolutional Turbo Code) blocks is currently limited to a maximum of 60 byte data blocks. Fragmenting large packets into many small blocks yields sub-optimal performance. The performance is affected adversely in two ways. First, performance gain from turbo codes decreases with smaller block sizes. Second, fewer (larger sized) blocks will have a better chance of successful transmission than more (smaller sized) blocks since all blocks must be successfully received for the packet to be successfully received.

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 CTC-IR mode. Optimized code performance (by increasing block size) should not be limited to CTC-IR, especially when it is straightforward to implement. Assuming a decoder is available to handle 600 byte data packets (max block size of CTC-IR), the added complexity to the original CTC implementation is negligible. 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 CTC-IR mode, will be optionally 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.

Examples are provided for a 576 byte and 1500 byte packet in the table below. With QPSK, Rate = _, 576 byte and 1500 byte MTU packets, yielding 96 and 250 sub-channels respectively. 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.

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

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 that the AWGN gains are ~1.2 dB (at 1e-4 FER) when larger blocksizes are employed. The second figure also shows the potential performance improvement with the new concatenation scheme for the 1500-byte packet.

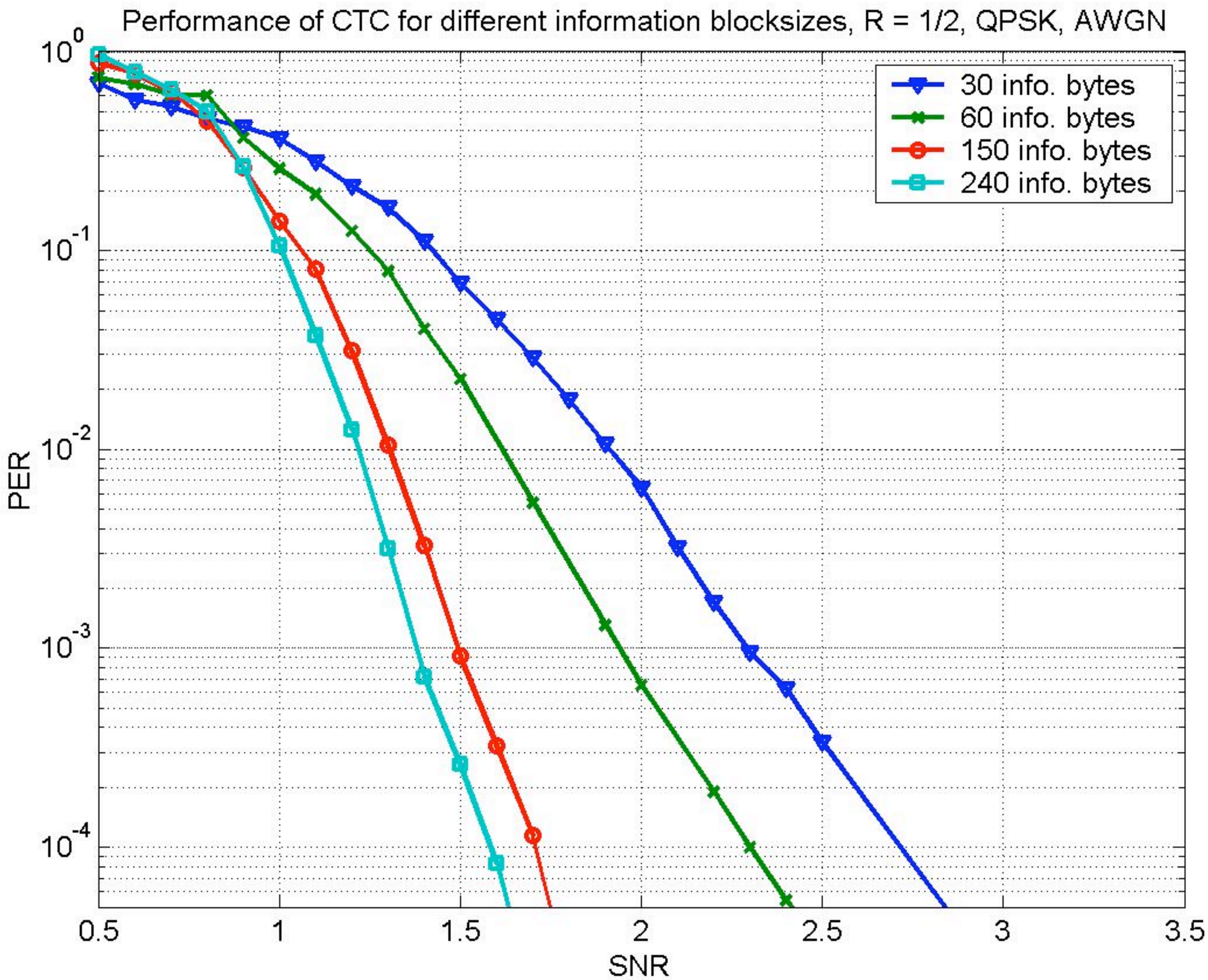

Figure 1 – Performance of CTC for different blocksizes

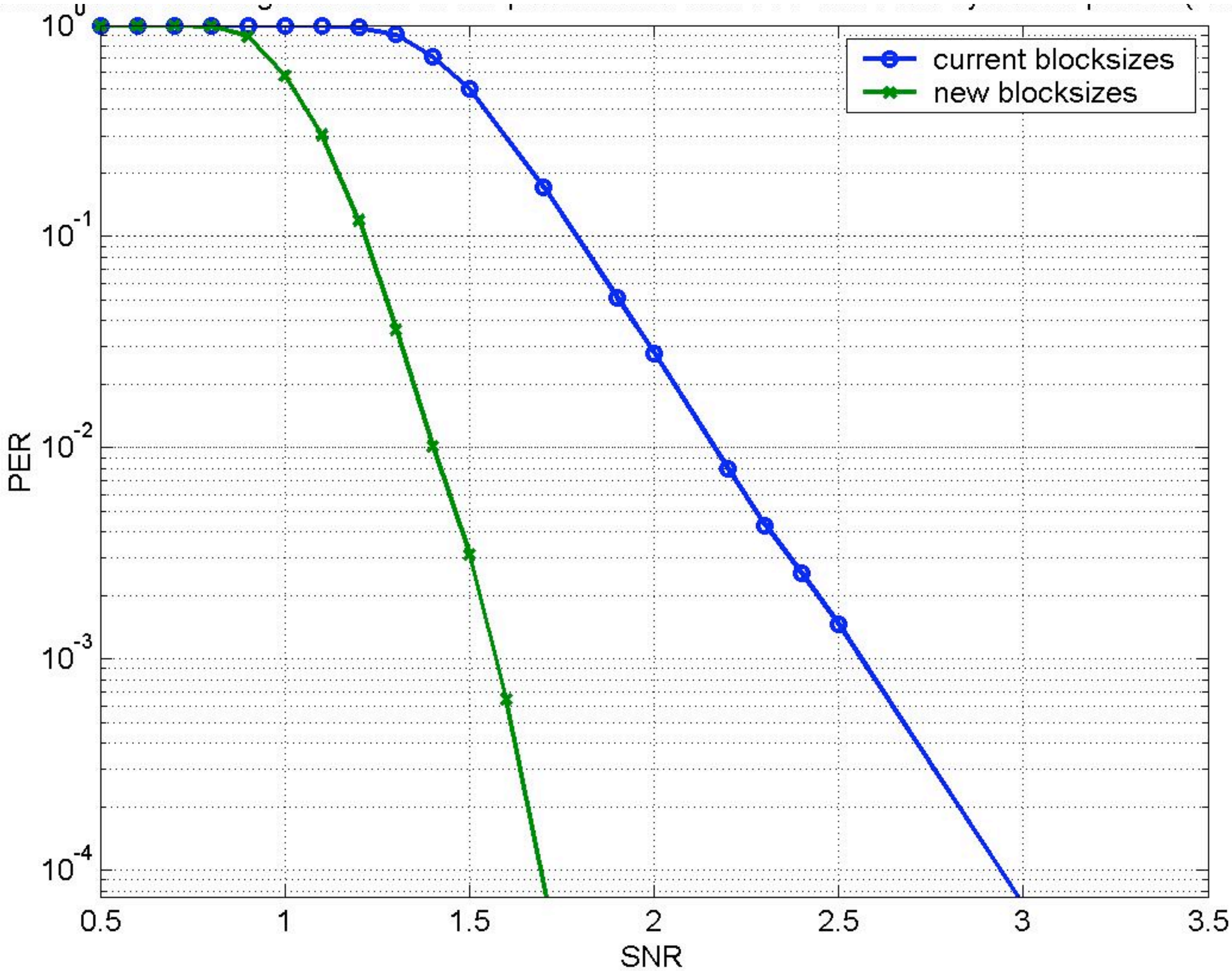

Figure 2 – Performance comparison of the current concatenation scheme and the proposed solution (1500 byte packet)

Recommended Text Changes:

Make the following changes to IEEE 802.16e/D7 (April 2005)

<Insert the following text on p. 243, line 38.>

In Table 268 and 268b, CTC will use the default block size of 60 bytes.

<Insert the following text p. 473 line 1.>
[Insert text at page 596 line 1 prior to the text "Table 324 shows the rules for subchannel concatenation"]

The parameter *j* is dependent on the maximum CTC information block size supported by both the base station and subscriber station. As a default, the maximum CTC information block size is 60 bytes when CTC is supported. The default maximum CTC information block size is used for all broadcast messaging when the information is intended for multiple subscribers. When supported by both the base station and mobile, the parameter *j* for the larger block sizes will be used for non-CTC-IR HARQ assignments.

<Note: Table 324 below preserves backwards compatibility when the maximum block size is set to 60 bytes>

[Replace Table 324 "Optimal CTC channel coding per modulation when supporting H-ARQ"with the following]

Table 324 – ***Optimal CTC channel coding per modulation when supporting H-ARQ"***

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
	if j=8 and m=7
	k blocks of j slots
	1 block of 4 slots
	1 block of 3 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)
	$L_{b1} = L_{b1} + 1$; $L_{b2} = L_{b2} - 1$;

[Insert the modifications to Table 325 on p. 473 line 27 of 802.16e/D7.]

Table 325 – Encoding subchannel concatenation for different rates in large-block-size CTC

Modulation and rate	*j* as a function of maximum block size		
	Max Size = 60 (default)	Max Size =120	Max Size = 240
QPSK 1/2	10	20	40
QPSK 3/4	6	13	26
QAM16 1/2	5	10	20
QAM16 3/4	3	6	13
QAM64 1/2	3	6	13
QAM64 2/3	2	5	10
QAM64 3/4	2	4	8
QAM64 5/6	2	4	8

Table 326 – Optional CTC channel coding per modulation

Modulation	Data Block Size (bytes)	Encoded Data Block Size (bytes)	Code rate	N	P0	P1	P2	P3
QPSK	6	12	1/2	24	5	0	0	0
QPSK	12	24	1/2	48	13	24	0	24
QPSK	18	36	1/2	72	11	6	0	6
QPSK	24	48	1/2	96	7	48	24	72
QPSK	30	60	1/2	120	13	60	0	60
QPSK	36	72	1/2	144	17	74	72	2
QPSK	48	96	1/2	192	11	96	48	144
QPSK	54	108	1/2	216	13	108	0	108
QPSK	60	120	1/2	240	13	120	60	180
QPSK	66	132	1/2	264	23	2	160	30
QPSK	72	144	1/2	288	23	50	188	50
QPSK	78	156	1/2	312	23	102	64	38
QPSK	90	180	1/2	360	29	56	0	68
QPSK	96	192	1/2	384	29	68	140	56
QPSK	102	204	1/2	408	29	124	204	40
QPSK	108	216	1/2	432	13	0	4	8
QPSK	114	228	1/2	456	31	100	224	104
QPSK	120	240	1/2	480	53	62	12	2
QPSK	132	264	1/2	528	31	24	36	104
QPSK	138	276	1/2	552	35	14	136	6
QPSK	144	288	1/2	576	31	42	232	18

QPSK	150	300	1/2	600	37	20	152	0
QPSK	156	312	1/2	624	37	312	156	468
QPSK	162	324	1/2	648	37	62	160	34
QPSK	174	348	1/2	696	37	0	128	12
QPSK	180	360	1/2	720	37	92	100	68
QPSK	186	372	1/2	744	37	54	196	50
QPSK	192	384	1/2	768	19	384	216	600
QPSK	198	396	1/2	792	41	0	228	24
QPSK	204	408	1/2	816	37	408	204	612
QPSK	216	432	1/2	864	19	2	16	6
QPSK	222	444	1/2	888	43	10	220	18
QPSK	228	456	1/2	912	43	96	8	124
QPSK	234	468	1/2	936	43	120	140	124
QPSK	240	480	1/2	960	43	64	300	824
QPSK	9	12	3/4	36	11	18	0	18
QPSK	18	24	3/4	72	11	6	0	6
QPSK	27	36	3/4	108	11	54	56	2
QPSK	36	48	3/4	144	17	74	72	2
QPSK	45	60	3/4	180	11	90	0	90
QPSK	54	72	3/4	216	13	108	0	108
QPSK	72	96	3/4	288	23	50	188	50
QPSK	81	108	3/4	324	11	172	164	16
QPSK	90	120	3/4	360	29	56	0	68
QPSK	99	132	3/4	396	29	36	128	76
QPSK	108	144	3/4	432	13	0	4	8
QPSK	117	156	3/4	468	31	98	220	98
QPSK	135	180	3/4	540	31	42	248	34
QPSK	144	192	3/4	576	31	42	232	18
QPSK	153	204	3/4	612	37	6	164	14
QPSK	162	216	3/4	648	37	62	160	34
QPSK	171	228	3/4	684	37	108	136	8
QPSK	180	240	3/4	720	37	92	100	68
QPSK	198	264	3/4	792	41	0	228	24
QPSK	207	276	3/4	828	41	136	288	192
QPSK	216	288	3/4	864	19	2	16	6
QPSK	225	300	3/4	900	43	8	56	20
QPSK	234	312	3/4	936	43	120	140	124
16-QAM	12	24	1/2	48	13	24	0	24
16-QAM	24	48	1/2	96	7	48	24	72
16-QAM	36	72	1/2	144	17	74	72	2
16-QAM	48	96	1/2	192	11	96	48	144
16-QAM	60	120	1/2	240	13	120	60	180
16-QAM	72	144	1/2	288	23	50	188	50
16-QAM	96	192	1/2	384	29	68	140	56
16-QAM	108	216	1/2	432	13	0	4	8
16-QAM	120	240	1/2	480	53	62	12	2
16-QAM	132	264	1/2	528	31	24	36	104
16-QAM	144	288	1/2	576	31	42	232	18

16-QAM	156	312	1/2	624	37	312	156	468
16-QAM	180	360	1/2	720	37	92	100	68
16-QAM	192	384	1/2	768	19	384	216	600
16-QAM	204	408	1/2	816	37	408	204	612
16-QAM	216	432	1/2	864	19	2	16	6
16-QAM	228	456	1/2	912	43	96	8	124
16-QAM	240	480	1/2	960	43	64	300	824
16-QAM	18	24	3/4	72	11	6	0	6
16-QAM	36	48	3/4	144	17	74	72	2
16-QAM	54	72	3/4	216	13	108	0	108
16-QAM	72	96	3/4	288	23	50	188	50
16-QAM	90	120	3/4	360	29	56	0	68
16-QAM	108	144	3/4	432	13	0	4	8
16-QAM	144	192	3/4	576	31	42	232	18
16-QAM	162	216	3/4	648	37	62	160	34
16-QAM	180	240	3/4	720	37	92	100	68
16-QAM	198	264	3/4	792	41	0	228	24
16-QAM	216	288	3/4	864	19	2	16	6
16-QAM	234	312	3/4	936	43	120	140	124
64-QAM	18	36	1/2	72	11	6	0	6
64-QAM	36	72	1/2	144	17	74	72	2
64-QAM	54	108	1/2	216	13	108	0	108
64-QAM	72	144	1/2	288	23	50	188	50
64-QAM	90	180	1/2	360	29	56	0	68
64-QAM	108	216	1/2	432	13	0	4	8
64-QAM	144	288	1/2	576	31	42	232	18
64-QAM	162	324	1/2	648	37	62	160	34
64-QAM	180	360	1/2	720	37	92	100	68
64-QAM	198	396	1/2	792	41	0	228	24
64-QAM	216	432	1/2	864	19	2	16	6
64-QAM	234	468	1/2	936	43	120	140	124
64-QAM	24	36	2/3	96	7	48	24	72
64-QAM	48	72	2/3	192	11	96	48	144
64-QAM	72	108	2/3	288	23	50	188	50
64-QAM	96	144	2/3	384	29	68	140	56
64-QAM	120	180	2/3	480	53	62	12	2
64-QAM	144	216	2/3	576	31	42	232	18
64-QAM	192	288	2/3	768	19	384	216	600
64-QAM	216	324	2/3	864	19	2	16	6
64-QAM	240	360	2/3	960	43	64	300	824
64-QAM	27	36	3/4	108	11	54	56	2
64-QAM	54	72	3/4	216	13	108	0	108
64-QAM	81	108	3/4	324	11	172	164	16
64-QAM	108	144	3/4	432	13	0	4	8
64-QAM	135	180	3/4	540	31	42	248	34
64-QAM	162	216	3/4	648	37	62	160	34
64-QAM	216	288	3/4	864	19	2	16	6
64-QAM	30	36	5/6	120	13	60	0	60

64-QAM	60	72	5/6	240	13	120	60	180
64-QAM	90	108	5/6	360	29	56	0	68
64-QAM	120	144	5/6	480	53	62	12	2
64-QAM	150	180	5/6	600	37	20	152	0
64-QAM	180	216	5/6	720	37	92	100	68
64-QAM	240	288	5/6	960	43	64	300	824

<Insert the following text on p. 474, line 57.>
8.4.9.2.3.4.2 Subblock interleaving
[Modify Table 329 as follows]

Table 329 – Parameters for subblock interleavers

Block size (bits) N_{EP}	N	Subblock Interleaver Parameters	
		m	J
48	24	3	3
72	36	4	3
96	48	4	3
144	72	5	3
192	96	5	3
216	108	6	3
240	120	6	2
288	144	6	3
360	180	6	3
384	192	6	3
432	216	6	4
480	240	7	2
528	264	7	3
576	288	7	3
624	312	7	3
648	324	7	3
720	360	7	3
768	384	7	3
792	396	7	4
816	408	7	4
864	432	7	4
912	456	8	2
936 960	468 480	8 8	2 2
1056	528	8	3
1080	540	8	3
1104	552	8	3
1152	576	8	3
1200	600	8	3
1224	612	8	3
1248	624	8	3
1296	648	8	3
1368	684	8	3
1392	696	8	3
1440	720	8	3
1488	744	8	3

1536	768	8	4
1584	792	8	4
1632	816	8	4
1656	828	8	4
1728	864	8	4
1776	888	8	4
1800	900	8	4
1824	912	8	4
1872	936	8	4
1920	960	9	2

<Add a new section 11.7.25, pg 529 line 27>

Section 11.7.25 CTC Maximum Encoder Block Size for Chase HARQ

A SS and BS which support CTC and Chase HARQ may optionally support larger CTC information block sizes. A SS supporting a larger block size will signal the capability of supporting larger block sizes in the REG-REQ message. A BS will respond with support for that block size or a smaller size in the REG-RSP. If SS does not signal this capability then it is assumed that the maximum block size is the default of 60 bytes. If a BS does support this capability then the BS responds with the default size of 60 bytes.

Type	Length	Value	Scope
18	1	0 – 60 bytes 1 – 120 bytes 2 – 240 bytes 3-255 reserved	REG-REQ REG-RSP