Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**On Concatenation of Block Turbo Codes for OFDMA**
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Re:	Response to the call for contributions to IEEE Standard 802.16-2004, IEEE 802.16maint-04/01, 2004-08-04. Header error fix toDeletion in IEEE 802.16maint-04/29r1.
Abstract	This contribution presents modifications to coding parameters of Block Turbo Codes for OFDMA in IEEE Standards Draft 5. With these modifications clarification is achieved. the code rate of every redesigned encoding patterns based on BTC will be exactly 1/2 or 3/4 and the information bits will have an exact multiple relations, not approximate as previous encoding patterns specified previously have.
Purpose	To incorporate the text modification proposed in this contribution into IEEE 802.16REVd standard.
Notice	
Release	
Patent Policy and Procedures	

On Concatenation of Block Turbo Codes for OFDMA

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1. Introduction

As an optional FEC scheme, BTC (Block Turbo Code), or TPC (Turbo Product Code) possesses many advantages over other FEC proposals in IEEE Standards Draft 5~~[1]~~, such as high code rate applications and superior BER Vs Eb/N0 performance~~, which have been pointed out in previous contributions on BTC, for example [2-4]~~. In IEEE Standards Draft 5, ~~And in [1],~~ ten optional encoding patterns based on BTC for OFDMA are provided, as listed in Table 320 and Table 321, on page 596-597 of Draft 5. But unfortunately, two coding parameters of them have the same coding rate 1/2 and coding bytes 16. So while form the value of UIUC we know that the coding pattern is QPSK 1/2, we cannot decide on which of them should be selected as the corresponding coding pattern. ~~However most of these coding patterns are not exactly 1/2 or 3/4 code rate, but approximately 1/2 or 3/4. This will impair effects of concatenation dramatically, and sometimes even make it impossible. While Concatenating, exact useful data payload and encoded data bytes are needed, and in fact we can obtain encoding patterns with exact code rate 1/2 and 3/4, not approximate. In the next section this will be detailed and an encoding scheme to replace those listed in Table 320 and Table 321 of [1] will be presented.~~

2. The Solution

We modify a few parameters in Table 320 and 321, such that the modification removes the above-mentioned ambiguity.

3. Proposed Text

Modify Table 320 and 321 as follows.

Table 320—Useful data payload for a subchannel

	QPSK		16-QAM		64-QAM		Coded Bytes
Encoding Rate	R=1/2	R=3/4	R=1/2	R=3/4	R=1/2	R=3/4	
Allowed Data (Bytes)	6	9					12
	~~16~~12	20	~~16~~12	20			24
	~~16~~18	25			~~16~~18	25	36
	23	35	23	35			48
	31						60
	40		40		40		72

Table 321—Optional channel coding per modulation

Data Bytes	Coded Bytes	Constituent	Code Parameters
6	12	(8,7)(32,26)	Ix=4,Iy=8,B=0,Q=6
9	12	(16,15)(16,15)	Ix=6,Iy=6,B=4,Q=5
~~16~~12	24	~~(8,7)(32,26)~~(32,31)(16,11)	Ix=14,Iy=5,B=6,Q=0~~Ix=2,Iy=0,B=0,Q=2~~
20	24	(16,15)(16,15)	Ix=2,Iy=2,B=4,Q=5
~~16~~18	36	~~(32,26)(16,11)~~(32,31)(16,11)	Ix=5,Iy=5,B=9,Q=3~~Ix=11,Iy=2,B=6,Q=7~~
25	36	(8,7) (64,57)	Ix=2,Iy=16,B=0,Q=5
23	48	(32,26)(16,11)	Ix=4,Iy=2,B=8,Q=6
35	48	(32,26)(16,15)	Ix=0,Iy=4,B=0,Q=6
31	60	(32, 26)(32,26)	Ix=10,Iy=10,B=4,Q=4
40	72	(32,26)(32,26)	Ix=8,Iy=8,B=0,Q=4

Modify Table 355 as follows.

Table 355—UCD burst profile encodings—WirelessMAN-OFDMA

Name	Type (1 byte)	length	Value (variable length)
FEC Code type and modulation type	150		0 = QPSK (CC) 1/2 1 = QPSK (CC) 3/4 2 = 16-QAM (CC) 1/2 3 = 16-QAM (CC) 3/4 4 = 64-QAM (CC) 2/3 5 = 64-QAM (CC) 3/4 6 = QPSK (BTC) 1/2 7 = QPSK (BTC) ~~2/3~~3/4 8 = 16-QAM (BTC) 3/5 9 = 16-QAM (BTC) 4/5 10 = 64-QAM (BTC) 5/8 11 = 64-QAM (BTC) 4/5 12 = QPSK (CTC) 1/2 13 = QPSK (CTC) 2/3 14 = QPSK (CTC) 3/4 15 = 16-QAM (CTC) 1/2 16 = 16-QAM (CTC) 3/4 17 = 64-QAM (CTC) 2/3 18 = 64-QAM (CTC) 3/4 19 = 64-QAM (CTC) 5/6 20 = QPSK (ZT CC) 1/2 21 = QPSK (ZT CC) 3/4 22= 16-QAM (ZT CC) 1/2 23= 16-QAM (ZT CC) 3/4 24= 64-QAM (ZT CC) 2/3 25= 64-QAM (ZT CC) 3/4 26..255 = *Reserved*
Ranging data ratio	151		Reducing factor in units of 1 dB, between the power used for this burst and power should be used for CDMA Ranging.
Normalized C/N override	152		This is a list of numbers, where each number is encoded by one nibble, and interpreted as a signed integer. The nibbles correspond in order to the list define by Table 332, starting from the second line, such that the LS nibble of the first byte corresponds to the second line in the table. The number encoded by each nibble represents the difference in normalized C/N relative to the previous line in the table.

~~Table 320'—**Useful data payload for a subchannel**~~

	~~**QPSK**~~		~~**16-QAM**~~		~~**64-QAM**~~		~~**Coded Bytes**~~
~~**Encoding Rate**~~	~~R=1/2~~	~~R=3/4~~	~~R=1/2~~	~~R=3/4~~	~~R=1/2~~	~~R=3/4~~	
~~**Allowed Data (Bytes)**~~	~~6~~	~~9~~					~~12~~
	~~12~~	~~18~~	~~12~~	~~18~~			~~24~~
	~~18~~	~~27~~			~~18~~	~~27~~	~~36~~
	~~24~~	~~36~~	~~24~~	~~36~~			~~48~~

	30						60
	36		36		36		72

Table 321—Optional channel coding per modulation

Data Bytes	Coded Bytes	Constituent	Code Parameters
6	12	(8,7)(32,26)	Ix=4,Iy=8,B=0,Q=6
9	12	(16,15)(16,15)	Ix=6,Iy=6,B=4,Q=5
16	24	(8,7)(32,26)	Ix=2,Iy=0,B=0,Q=2
20	24	(16,15)(16,15)	Ix=2,Iy=2,B=4,Q=5
16	36	(32,26)(16,11)	Ix=11,Iy=2,B=6,Q=7
25	36	(8,7) (64,57)	Ix=2,Iy=16,B=0,Q=5
23	48	(32,26)(16,11)	Ix=4,Iy=2,B=8,Q=6
35	48	(32,26)(16,15)	Ix=0,Iy=4,B=0,Q=6
31	60	(32, 26)(32,26)	Ix=10,Iy=10,B=4,Q=4
40	72	(32,26)(32,26)	Ix=8,Iy=8,B=0,Q=4

Substituted by →

Table 321'—Optional channel coding per modulation

Data Bytes	Coded Bytes	Constituent	Code Parameters
6	12	(8,7)(16,11)	Ix=0,Iy=4,B=0,Q=1
9	12	(8,7)(16,15)	Ix=0,Iy=4,B=0,Q=5
12	24	(32,31) (16,11)	Ix=14,Iy=5,B=6,Q=0
18	24	(64,63) (8,7)	Ix=24,Iy=3,B=8,Q=4
18	36	(32,31) (16,11)	Ix=5,Iy=5,B=9,Q=3
27	36	(64,63) (8,7)	Ix=3,Iy=3,B=17,Q=7
24	48	(32,26) (16, 11)	Ix=6,Iy=1,B=6,Q=2
36	48	(128,127)(8,7)	Ix=42,Iy=3,B=46,Q=6
30	60	(32, 26)(32,26)	Ix=2,Iy=16,B=0,Q=0
36	72	(64, 57)(64,57)	Ix=40,Iy=40,B=0,Q=1

Data Bytes	Coded Bytes	Constituent	Code Parameters
6	12	(8,7)(16,11)	Ix=0,Iy=4,B=0,Q=1
12	24	(32,31) (16,11)	Ix=14,Iy=5,B=6,Q=0
18	36	(32,31) (16,11)	Ix=5,Iy=5,B=9,Q=3

24	48	(32,26) (16, 11)	Ix=6,Iy=1,B=6,Q=2
30	60	(32, 26)(32,26)	Ix=2,Iy=16,B=0,Q=0
36	72	(64, 57)(64,57)	Ix=40,Iy=40,B=0,Q=1
9	12	(8,7)(16,15)	Ix=0,Iy=4,B=0,Q=5
18	24	(64,63) (8,7)	Ix=24,Iy=3,B=8,Q=4
27	36	(64,63) (8,7)	Ix=3,Iy=3,B=17,Q=7
36	48	(128,127)(8,7)	Ix=42,Iy=3,B=46,Q=6

1)**UCD burst profile encodings of BTC** in Table 355, on page 663 of [1] should also be modified correspondingly, namely:

Table 355 —UCD burst profile encodings—WirelessMAN-OFDMA

Name	Type (1 byte)	Length	Value (variable length)
FEC Code type and modulation type	150	1	0 = QPSK (CC) 1/2 14 = QPSK (CTC) 3/4 1 = QPSK (CC) 3/4 15 = 16-QAM (CTC) 1/2 2 = 16-QAM (CC) 1/2 16 = 16-QAM (CTC) 3/4 3 = 16-QAM (CC) 3/4 17 = 64-QAM (CTC) 2/3 4 = 64-QAM (CC) 2/3 18 = 64-QAM (CTC) 3/4 5 = 64-QAM (CC) 3/4 19 = 64-QAM (CTC) 5/6 6 = QPSK (BTC) 1/2 20 = QPSK (ZT CC) 1/2 7 = QPSK (BTC) 2/3 21 = QPSK (ZT CC) 3/4 8 = 16-QAM (BTC) 3/5 22= 16-QAM (ZT CC) 1/2 9 = 16-QAM (BTC) 4/5 23= 16-QAM (ZT CC) 3/4 10 = 64-QAM (BTC) 5/8 24= 64-QAM (ZT CC) 2/3 11 = 64-QAM (BTC) 4/5 25= 64-QAM (ZT CC) 3/4 12 = QPSK (CTC) 1/2 26..255 = *Reserved* 13 = QPSK (CTC) 2/3
Ranging data ratio	151	1	Reducing factor in units of 1 dB, between the power used for this burst and power should be used for CDMA Ranging.
Normalized C/N override	152	5	This is a list of numbers, where each number is encoded by one nibble, and interpreted as a signed integer. The nibbles correspond in order to the list define by Table 332, starting from the second line, such that the LS nibble of the first byte corresponds to the second line in the table. The number encoded by each nibble represents the difference in normalized C/N relative to the previous line in the table.

Substituted by →

Table 355' —UCD burst profile encodings—WirelessMAN-OFDMA

Name	Type (1 byte)	Length	Value (variable length)
FEC Code type and modulation type	150	1	0 = QPSK (CC) 1/2 14 = QPSK (CTC) 3/4 1 = QPSK (CC) 3/4 15 = 16-QAM (CTC) 1/2 2 = 16-QAM (CC) 1/2 16 = 16-QAM (CTC) 3/4 3 = 16-QAM (CC) 3/4 17 = 64-QAM (CTC) 2/3 4 = 64-QAM (CC) 2/3 18 = 64-QAM (CTC) 3/4 5 = 64-QAM (CC) 3/4 19 = 64-QAM (CTC) 5/6 6 = QPSK (BTC) 1/2 20 = QPSK (ZT CC) 1/2 7 = QPSK (BTC) 3/4 21 = QPSK (ZT CC) 3/4 8 = 16-QAM (BTC) 1/2 22= 16-QAM (ZT CC) 1/2 9 = 16-QAM (BTC) 3/4 23= 16-QAM (ZT CC) 3/4 10 = 64-QAM (BTC) 1/2 24= 64-QAM (ZT CC) 2/3 11 = 64-QAM (BTC) 3/4 25= 64-QAM (ZT CC) 3/4 12 = QPSK (CTC) 1/2 26..255 = *Reserved* 13 = QPSK (CTC) 2/3

Ranging data ratio	151	1	Reducing factor in units of 1 dB, between the power used for this burst and power should be used for CDMA Ranging.
Normalized C/N override	152	5	This is a list of numbers, where each number is encoded by one nibble, and interpreted as a signed integer. The nibbles correspond in order to the list define by Table 332, starting from the second line, such that the LS nibble of the first byte corresponds to the second line in the table. The number encoded by each nibble represents the difference in normalized C/N relative to the previous line in the table.

References:

1, IEEE 802.16.1pc-00/35, "Turbo Product Code FEC Contribution"

2, IEEE 802.16.1pc-00/43, "FEC proposal: use of Block Turbo Code (BTC) for IEEE 802.16.1 Air Interface Standard"

3, IEEE 802.16.3p-01/05, "IEEE 802.16.3 PHY Utilizing Turbo Product Codes"

4, IEEE P802.16-REVd/D5-2004, Draft IEEE Standard for Local and metropolitan area networks Part 16: Air Interface for Fixed Broadband Wireless Access Systems