Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**FEC performance for 802.16.3 OFDM**
Date Submitted	**2001-05-07**
Source(s)	Tal Kaitz BreezeCOM Ltd. Atidim Technology Park Bldg. 1 P.O.B 13139 Tel Aviv 61131 Israel Voice: + 972 3 6456273/262 Fax: + 972 3 6456222/290 mailto: talk@breezecom.co.il
Re:	
Abstract	The performance of the proposed Forward Error Correction (FEC) Scheme for 802.16.3 OFDM PHY is investigated. The proposed scheme employs a concatenated Reed- Solomon and a convolutional code, with relatively short blocks. It is shown that due to the short block lengths employed, the proposed scheme is inefficient, and that there are more efficient and simpler schemes. In particular, it is shown that the rate equivalent convolution code performs as well as the proposed concatenated scheme.
Purpose	Aid in the selection of the FEC scheme.
Notice	
Release	
Patent Policy and Procedures	

FEC Performance of the proposed 802.16.3 OFDM PHY

Tal Kaitz, BreezeCOM

1. Introduction

In the proposed 2-11GHz air interface draft [1], a Forward Error Correction (FEC) scheme is defined. This scheme utilizes concatenated Reed Solomon block codes with a tail-biting convolution code. The block lengths of the resulting code are matched to the OFDM symbol size. As a result, the block lengths are dependent on the modulation alphabet, and are in the range of 24…108 bytes.

In a recent submission ([2]) to the OFDM ad-hoc group, C. Cahn and A.W Wang demonstrated that for the ideal BPSK/QPSK channel, the proposed schemes are be inefficient due to the short block lengths.

In this submission, more simulation results are shown for the bit interleaved coded modulation (BICM) channel. The performance of the proposed concatenated schemes, are compared with an equivalent rate, convolutional code (CC), and with a concatenated code using a RS(255,239,8) code.

The results indicate, that at a Packet error rate of 1% (for 1000 bytes packets), CC alone is either equal or better to its equivalent concatenated code using short blocks. Alternatively, longer blocks can be used for the RS outer code, resulting in a significant performance improvement.

2. Coding schemes under consideration

In this submission three coding schemes are considered:

1. The proposed concatenated RS code and a convoultional code (CC). The CC used is the standard rate=1/2 K=7 with generator polynomials 171_8 and 133_8. The CC is punctured to a desired rate. The parameters of block length puncturing and RS code are given in Table 1.

Modulation	Over all code rate	Block lengths (Bytes)	RS parameters (N,K,T)	CC Code rate
QPSK	_	24	(32,24,4)	2/3
QPSK	_	36	(40,36,2)	5/6
QAM16	_	48	(64,48,8)	2/3
QAM16	_	72	(80,72,4)	5/6
QAM64	_	96	(108,96,6)	_
QAM64	_	108	(120,108,6)	5/6

Table 1 Concatenated Coding schemes

2. Zero tail convolutional code with rate=1/2 K=7. The code is continuous over the entire message and is terminated at the end of the massage by inserting 6 zero bits. The code is punctured to the desired rate.
3. A concatenated scheme using a (255,239,8) RS code and a punctured convolutional code. The overall rate of this scheme is about 6% lower then the other 2 schemes. This may be translated to a loss in Eb/No of 0.3dB.

3. Simulation results

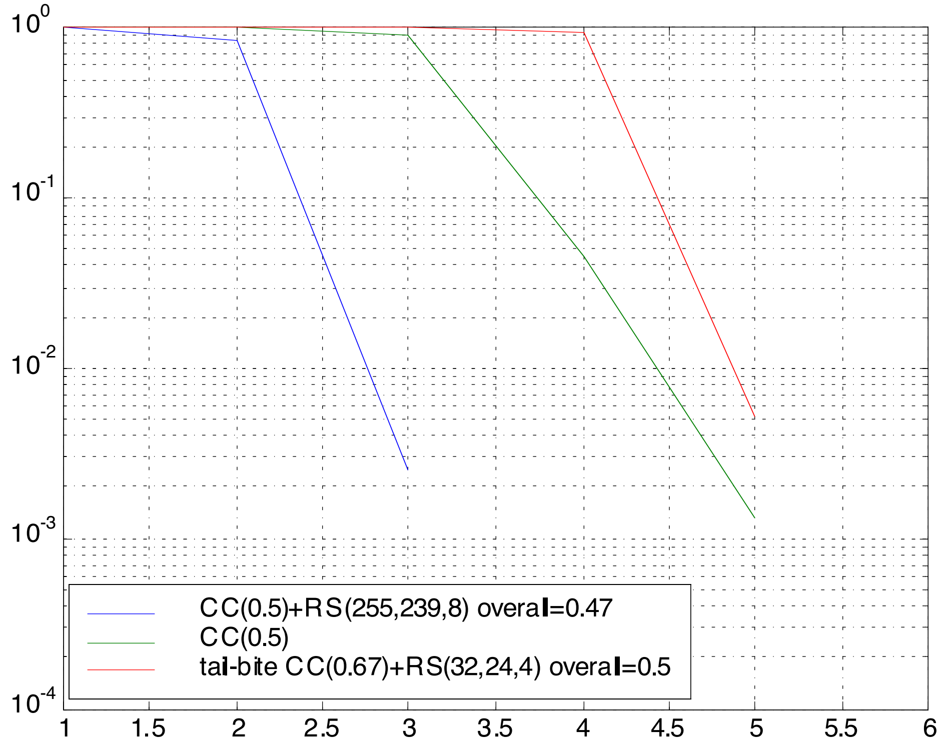
The performance of the three coding schemes was evaluated using simulation. The conditions for the simulations are as follows:

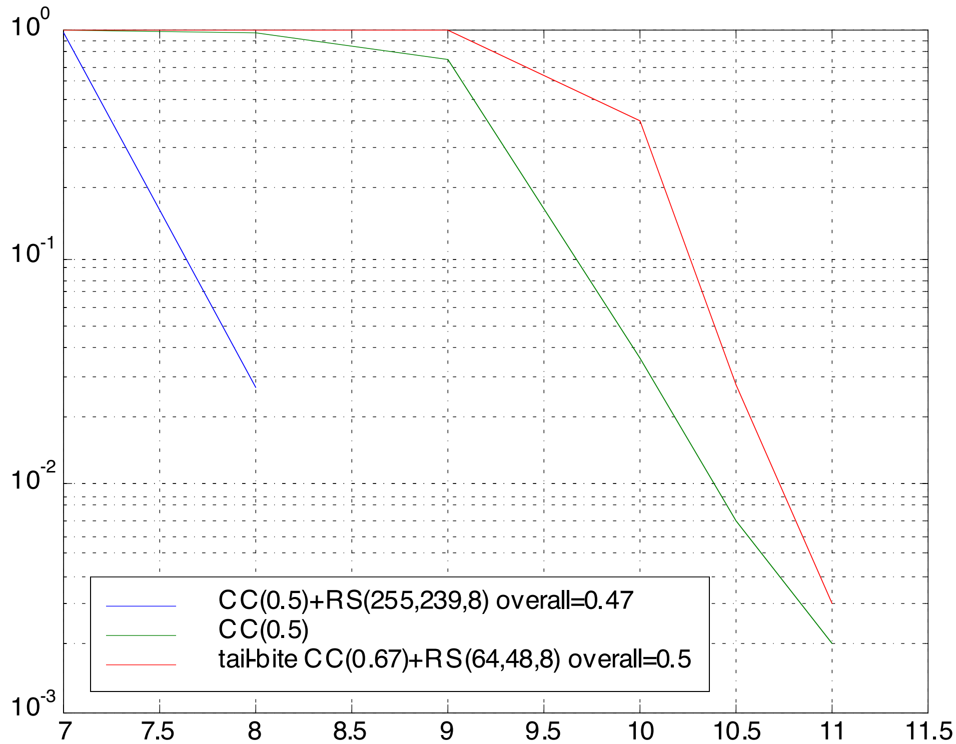
1. The modulation waveform was OFDM with FFT size of 256 and channel spacing of 3.5MHz.

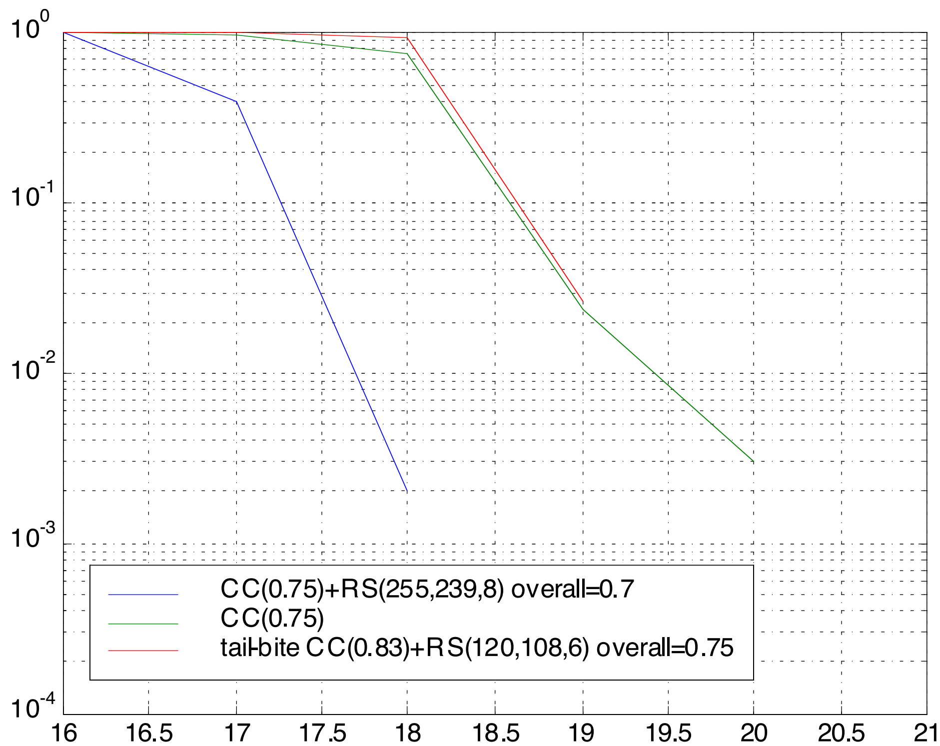
2. Packet size of about 1000 bytes. The exact size is determined to be an integer number of RS blocks.
3. Ideal channel and frequency offset estimation was assumed.
4. In all cases presented, 1000 packets were simulated.
5. SUI models ,[3], number 3 and 4 were used to simulate multipath conditions.

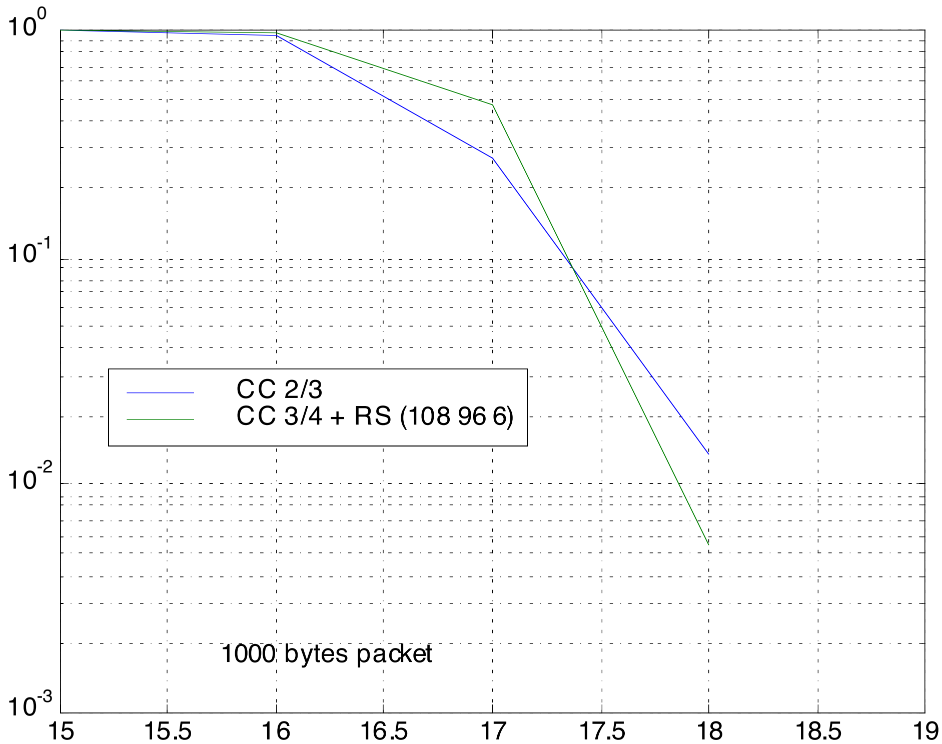
In all cases, the packet error rate is shown as a function of signal to noise ratio, at the output of the FFT.

3.1 AWGN case

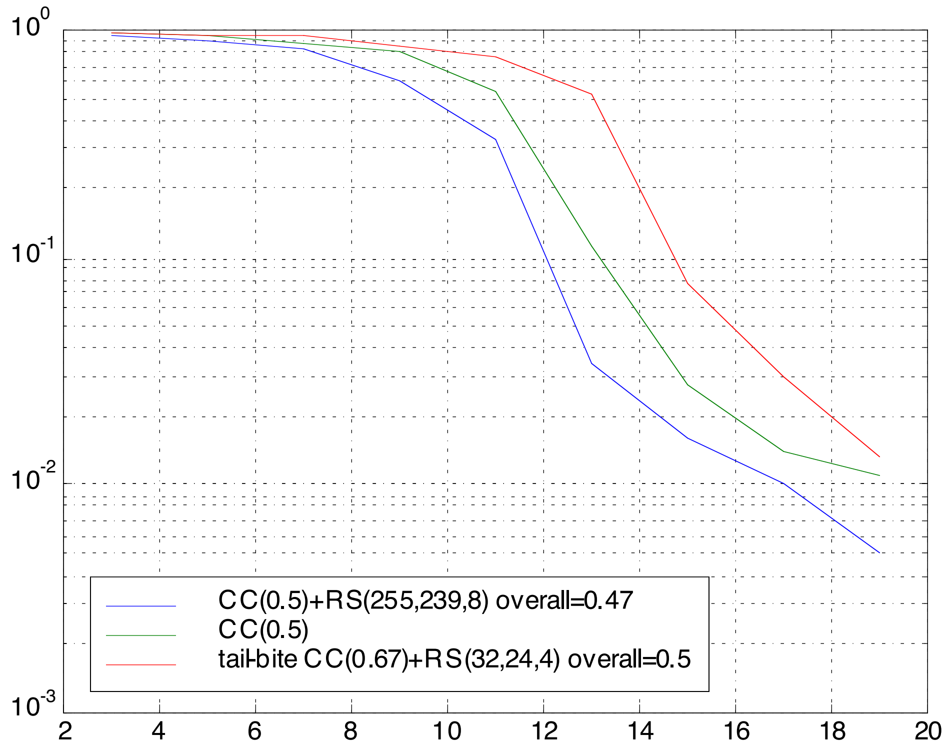


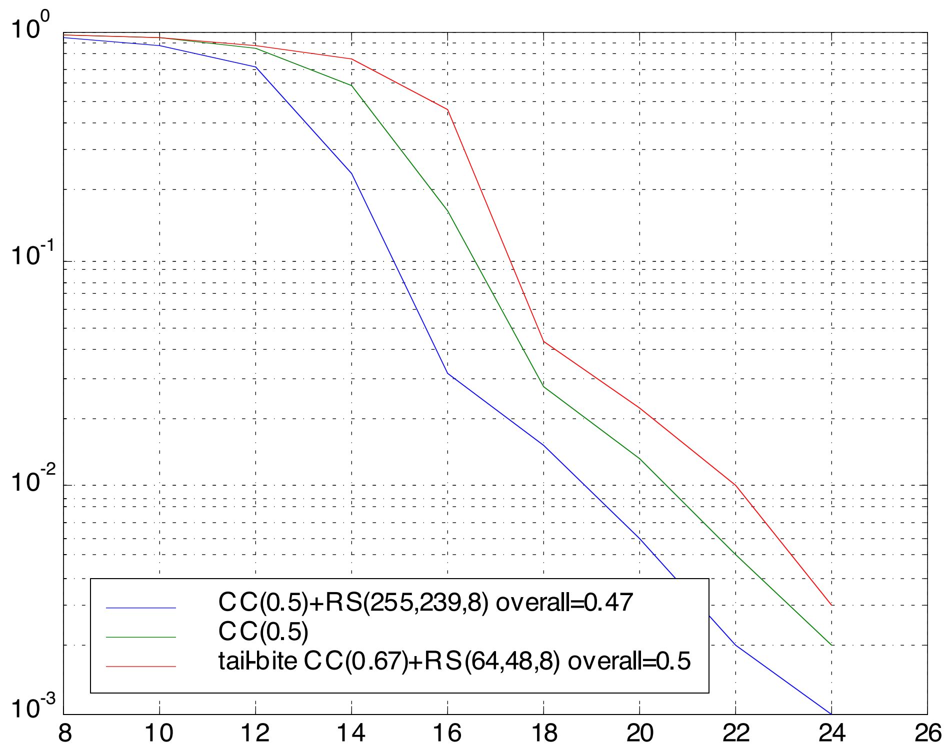

10^0
10^-1
10^-2
10^-3
7
7.5
8
8.5
9
9.5
10
10.5
11
11.5
CC(0.5)+RS(255,239,8) overall=0.47
CC(0.5)
tail-bite CC(0.67)+RS(64,48,8) overall=0.5

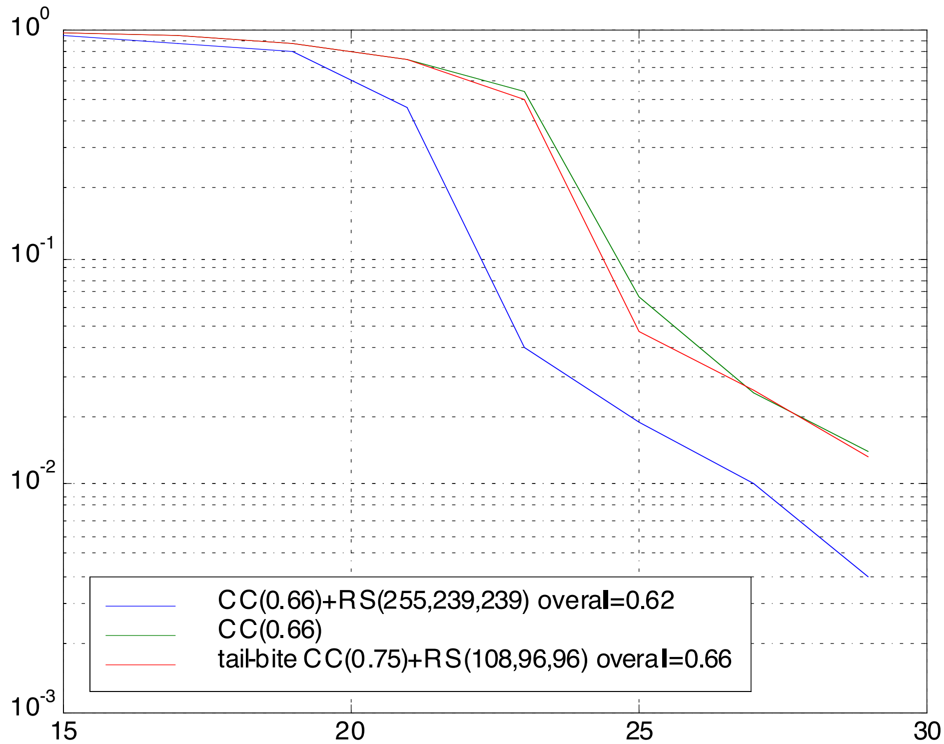

10^0
10^-1
10^-2
10^-3
10^-4
16
16.5
17
17.5
18
18.5
19
19.5
20
20.5
21
CC(0.75)+RS(255,239,8) overall=0.7
CC(0.75)
tail-bite CC(0.83)+RS(120,108,6) overall=0.75

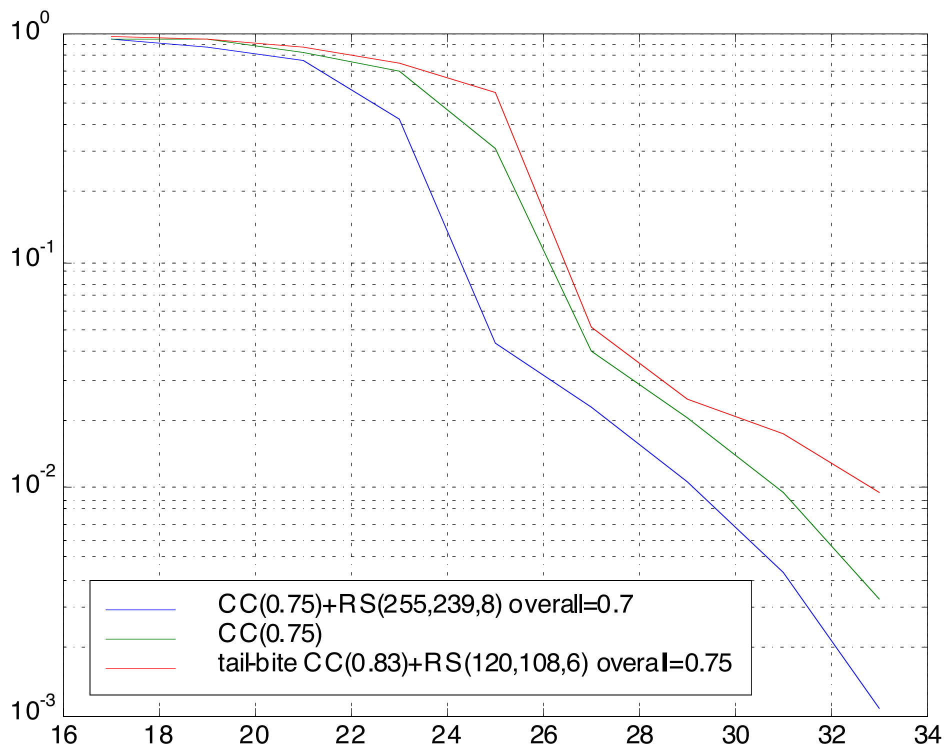


3.2 Multipath Case


CC(0.5)+RS(255,239,8) overall=0.47
CC(0.5)
tail-bite CC(0.67)+RS(32,24,4) overall=0.5


CC(0.5)+RS(255,239,8) overall=0.47
CC(0.5)
tail-bite CC(0.67)+RS(64,48,8) overall=0.5


CC(0.66)+RS(255,239,239) overall=0.62
CC(0.66)
tail-bite CC(0.75)+RS(108,96,96) overall=0.66
10^0
10^-1
10^-2
10^-3
15
20
25
30


CC(0.75)+RS(255,239,8) overall=0.7
CC(0.75)
tail-bite CC(0.83)+RS(120,108,6) overall=0.75
10^0
10^-1
10^-2
10^-3
16
18
20
22
24
26
28
30
32
34

4. Conclusions

For both AWGN and SUI channels, at a packet error rate of about 1% (for 1000 bytes packets), the performance of the CC alone is better or equal to the performance of the concatenated code using short block codes. At lower packet error rates, and for QAM64 modulation the concatenated schemes may have better performance. This requires further study.

For all cases, concatenated schemes using the full block lengths outperformed the other two schemes by 1.5-2 dB. It should be noted however, that the bit rate is lower by about 6%.

As a conclusion, we should consider two alternatives:

1. Use the CC code without concatenation, suffering no performance penalty in comparison with the scheme of the current draft and greatly simplifying the FEC block.
2. Increase the block length of the RS code to the full (255,239) to gain a significant SNR improvement.

5. References

[1] IEEE 802.16ab-01/01 : Air Interface for Fixed Broadband Wireless Acess Systems Part A: System between 2 and 11GHz

[2] Charlie Cahn, Arthur W. Wang, '*A STUDY OF THE BENEFIT OF CONCATENTATED CODING IN IEEE 802.16',* a submission to the OFDM ad-hoc group.

[3] 802.16.3c-01/29r1 , 'Channel Models for Fixed Wireless Applications' V. Erceg, K.V.S. Hari, M.S. Smith, D.S. Baum, K.P. Sheikh, C. Tappenden, J.M. Costa, C. Bushue, A. Sarajedini, R. Schwartz, D. Branlund,