Reflections on FEC Ad-Hoc group resolutions

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Reflections on ‘FEC Ad-Hoc Group’ Resolutions

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Background

- One of the topics discussed in the FEC ad-hoc:

  ‘Optimality of the current FEC scheme’
- Current draft (TG3) uses outer RS + inner CC.
  - With very short block lengths. Different from standard practice.
- Comparison with CC only showed that:
  - CC better then RS+CC @ PER >10^{-2}… 10^{-3}
  - RS+CC is better at PER < 10^{-2}… 10^{-3}
  - Cross over points depends on the block length and rate.
- Decision was taken to adopt RS+CC as mandatory mode for TG4.
  - Hence RS+CC is the mandatory scheme for OFDM/OFDMA

Background (cntd).

- Authors feel that this decision is technically wrong.
  - Will increase complexity with no real gain.
  - In this contribution, we shall try to convince the working group on this.
- Please note:
  - A technical debate.
  - Ad hoc procedures were immaculate.

  ☺ Thnx Garik for chairing the ad-hoc.

Outline

- Summary of simulations results presented
- Discussion points:
  - At what PER to compare ?
  - “It’s unthinkable not to use RS”
  - Can RS erasures be used ?
  - Can the number of RS corrections be used as a redundancy check ?

Simulations results

- Simulation results from 5 individuals
  - Charlie Chan (Who brought up this issue)
  - Einan Regev, Yossi Segal, Brian Edmonston, Tal Kaitz

Summary of results

Source	Conditions	Results	@ $P_{error/byte}$
Charlie	QPSK ½ AWGN	CC better by 0.5 dB.	$1.3 \cdot 10^{-5}$
Brian	QPSK ½ AWGN	CC better by 0.4 dB	$4 \cdot 10^{-4}$
Brian	QAM16 ¾ AWGN	CC better by 0.4 dB	$1.2 \cdot 10^{-4}$
Einan	QPSK 1/2- QAM64 3/4 SUI #1	CC better by ~1dB In all cases	10^{-4}…10^{-5}

Summary of results, cntd

Source	Conditions	Results	@ $P_{error/byte}$
Tal	QAM16 ½ AWGN	CC better by 0.4 dB.	$1 \cdot 10^{-5}$
Tal	QAM 64 ¾ AWGN	CC and RSV equal	$2 \cdot 10^{-5}$
Tal	QAM 64 2/3 AWGN	CC and RSV equal	10^{-4}
Tal	QAM16 ½ SUI #3 4Mhz	CC better by 1.7dB	10^{-5}

Summary of results, cntd

Source	Conditions	Results	@ $P_{error\ /byte}$
Yossi	QAM16 ½ AWGN	CC and RSV equal. RSV+Erasure better then CC by 0.7dB	$1 \cdot 10^{-5}$
Yossi	QAM 16 ¾ AWGN	CC better by 0.2dB RSV+Erasure Better by 0.8	$1 \cdot 10^{-5}$
Yossi	QAM 64 2/3 SUI#1 20MHz	RSV better than CC by 1.5 dB RSV+Erasure better than CC by 1.7dB	$3 \cdot 10^{-4}$
Yossi	QPSK ½ SUI#1	RSV equal CC	$4 \cdot 10^{-5}$

Results

- Majority of contributors:

- CC is better at 10^{-5} error event /byte.
- RS+CC is better at lower error probabilities.

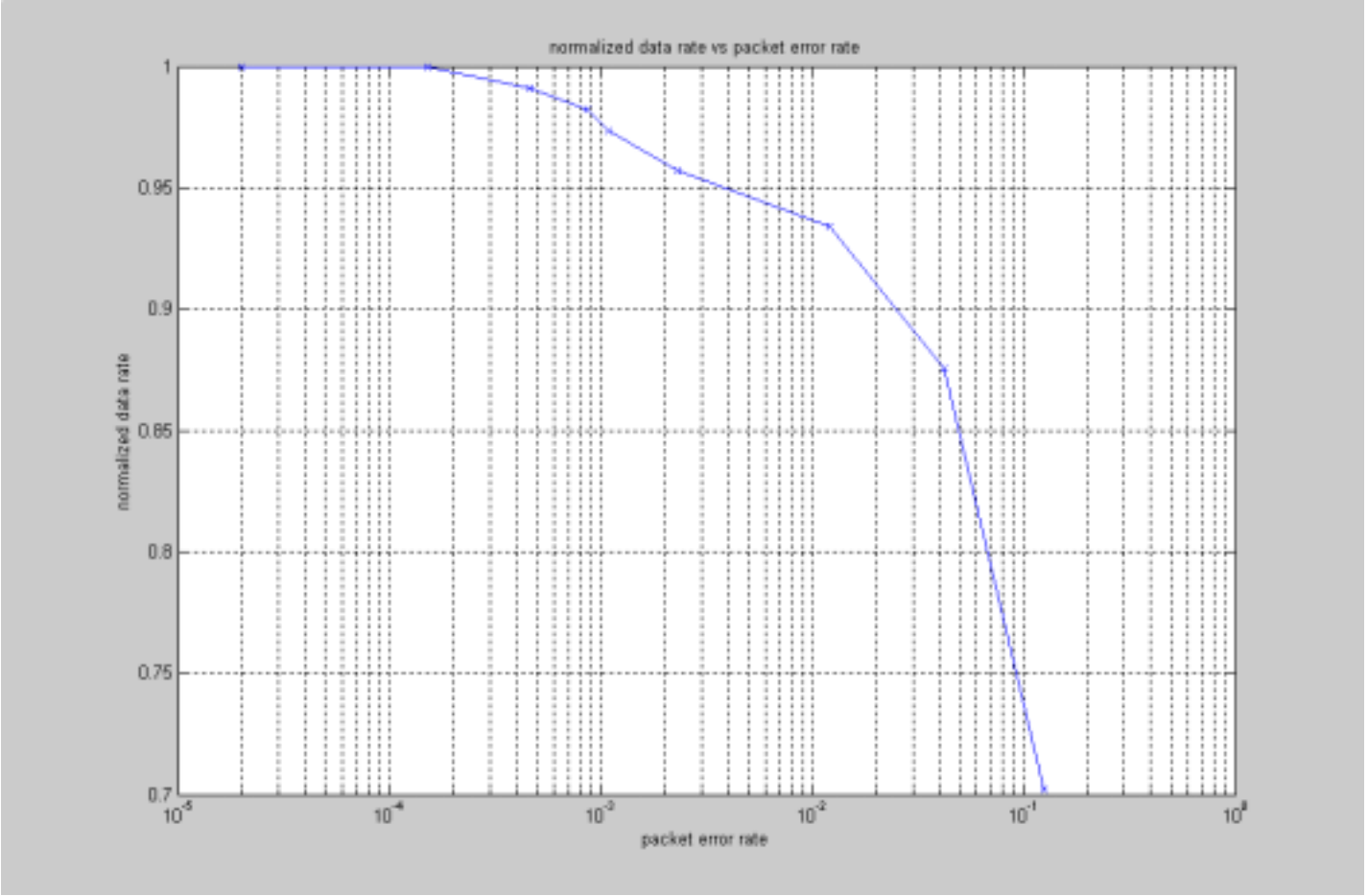
- Disagreement with Yossi on Multipath results. (Not same conditions were simulated)
- Yossi showed the advantage of using soft output and erasures.

At what PER to compare

- What code is better depends on required PER.
- ARQ systems can operate well with PER 10^{-2} … 10^{-3}
- Degradation due TCP/IP

Degradation due to TCP

Source: Wendy Wang, Aperto Networks



Degradation due to TCP

- Octavian's point:
  - Our system has 6-8 modes, rates for two consecutive MODES is 1.33…1.5, and the SNR difference is 2-3dB.
  - Suppose we operate at MODE4 with an SNR that provides say PER=10^-2.
  - According to Wendy, this will reduce our throughput to 93%.
  - We panic (TCP) and switch to mode3 which is 66% data rate.
  - 93%* 100% <> 100% *66 % ?

  By requiring very low PER we reduce efficiency

PER working point

- PER is not governed by FEC alone:
  - Fades, interference may govern
- Under fades or interference we experience a temporal loss of SNR.
  - Momentarily we'll be in high PER region
  - At this point FEC performance will be crucial.

“RS+CC have been around”

- We have nothing against concatenated schemes.
- A properly designed RS+CC with long blocks will perform well even in high PER.
- The common practice is add the outer scheme without reducing the inner CC.
- In our scheme the CC rate is weakened to keep overall rate as is.
- This significantly weakens the code.

Use of erasures

- Performance maybe improved by using Viterbi soft outputs and erasures:
- Literature[1] (Zeoli 1973) shows 0.3 dB in QPSK.
- Yossi showed higher improvements for multipath. Requires further study.

[1] G.W. Zeoli, "Coupled Decoding of Block-Convolutional Concatenated Codes", IEEE Trans on Comm, vol COM-21 1973, M Charlie Cahn provide this reference

Use of erasures

- To use erasures we need to provide soft output from Viterbi decoder.
- Requires changes and additional complexity of Viterbi decoder.
- No longer an off the shelf design block
- If you want to give your product an edge: use turbo codes which are now defined.

Can we use RS as redundancy check ?

- Yes but at expense of error correction capability.
- The number of corrections can be used only as a ‘quality indicator’ of received payload.
- This can be done also in CC case, by computing un-coded BER.

Summary

- The current FEC scheme is not optimal
- At packet error rates of interest, this systems performs worse then a simpler convoutional code.
- It can be enhanced by using erasure but
  - At major increased complexity
  - With questionable benefits
  - We already have an advanced FEC (Turbo)
- It is different from the standard practice.

Conclusions

- Let’s not use a complicated system instead of a simpler and a better one

- We believe that CC should be the mandatory scheme for 16a (OFDM) and 16b.