doc.: IEEE 802.11-98/82a

Proposal for High Data Rate 2.4 GHz PHY

Variable Rate
Binary Convolutional Coding
on QPSK

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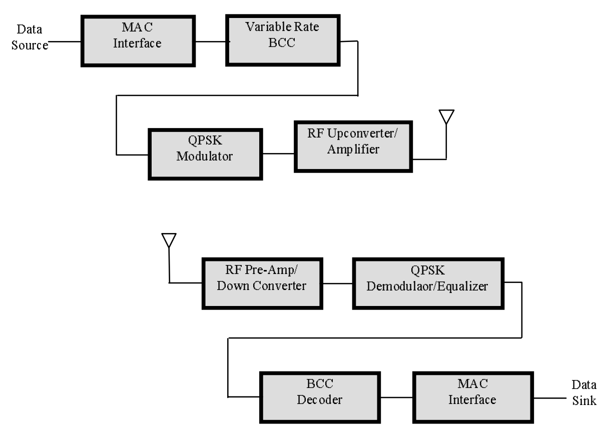
Submission

Transmitter & Receiver



Robust Coding

- 64 state BCC (binary convolutional code) with punctured rate
- (uncoded) 1, 2, (coded) 2.75, 5.5, 11, 14.3, 16.5, 17.6, 18.3 and 19.25 Mbps
- primary rate: 11 Mbps with +2dB Es/No over 2Mbps DS-PHY (+500% data)
- 5.5 Mbps with -1.2dB Es/No over 2Mbps DS-PHY (+275% data)
- More coding gain can save power at transmitter

Backward Compatibility

- QPSK modulation
- Channelization
  - 11 Msps Symbol (Chip) Rate
  - 30 MHz Bandwidth
- Existing RF, Antenna, MAC
- Preamble
  - Existing preamble
    - most compatible, less data/estimation efficient
    - high performance preamble

Complexity

- Estimates of 76k-95k gates

QPSK Demodulator/Equalizer	44k-55k
BCC Decoder	28k-35k
MAC Interface	4k-5k
TOTAL	76k-95k

  - modest in terms of state-of-the art technology today
  - estimates based on preliminary HDL design (portable)
- Power management will reduce average power usage (modules with have sleep mode, CMOS)
- Technical feasibility demonstrated; at least one vendor has already agreed to deploy the system
- A low complexity solution that is not robust will hurt the possibility of exciting growth in the WLAN market -we all lose...

BCC's in Wireless Systems

- The use of BCC's in wireless communications is not a new idea
- BCC's have been proven effective in wireless systems with multipath, and they have been implemented as commercial products
- IS-95 standard for digital CDMA cellular phones uses a 256-state BCC
- GSM standard uses a four state punctured BCC
- Satellite systems, such as the small disk digital TV systems (e.g., DirectTV & Primestar) always deploy such a BCC
- In addition, BCC's have been proposed for the 802.11A (5.0 GHz) systems

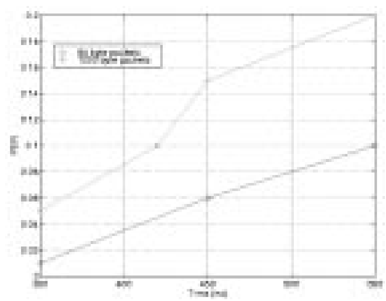
Processing Gain

Code System	Mod	Data Rate (@11MHz)	Code R (bits/sym)	C.G.	W. G.	R.G.	P.G.
11 Barker	BPSK	1Mbps	1/11	0dB	4.3dB	13.4dB	17.7dB
11 Barker	QPSK	2Mbps	2/11	0dB	4.3dB	10.4dB	14.7dB
(4,1) v=6 BCC	BPSK	2.75Mbps	1/4	5.6dB	4.3dB	9.0dB	18.9dB
(4,1) v=6 BCC	QPSK	5.5Mbps	1/2	5.6dB	4.3dB	6.0dB	15.9dB
(2,1) v=6 BCC	QPSK	11Mbps	1	5.4dB	4.3dB	3.0dB	12.7dB
(3,2) v=6 BCC	QPSK	14.6Mbps	4/3	5.2dB	4.3dB	1.8dB	11.3dB
(4,3) v=6 BCC	QPSK	16.5Mbps	3/2	4.5dB	4.3dB	1.2dB	10.0dB
(5,4) v=6 BCC	QPSK	17.6Mbps	8/5	4.2dB	4.3dB	1.0dB	9.5dB
(6,5) v=6 BCC	QPSK	18.3Mbps	5/3	4.1dB	4.3dB	0.8dB	9.2dB
(8,7) v=6 BCC	QPSK	19.2Mbps	14/8	4.0dB	4.3dB	0.6dB	8.9dB

AWGN Performance Detection Complexity

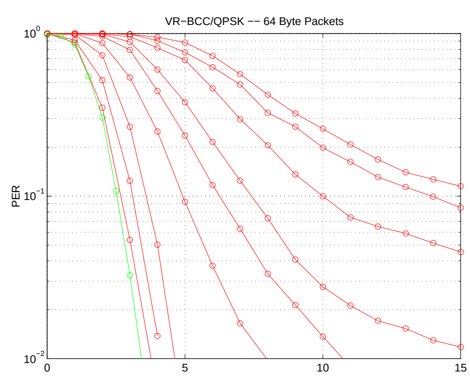
Code System	Mod	Data Rate (@11MHz)	Code R (bits/sym)	Es/No (10^{-5})	Eb/No (10^{-5})	Adds (per bit)	Cmps (per bit)
11 Barker	BPSK	1Mbps	1/11	-0.7dB	9.7dB	10	1
11 Barker	QPSK	2Mbps	2/11	2.3dB	9.7dB	10	1
(4,1) v=6 BCC	BPSK	2.75Mbps	1/4	-1.9dB	4.1dB	152	64
(4,1) v=6 BCC	QPSK	5.5Mbps	1/2	1.1dB	4.1dB	152	64
(2,1) v=6 BCC	QPSK	11Mbps	1	4.3dB	4.3dB	132	64
(3,2) v=6 BCC	QPSK	14.6Mbps	4/3	2.7dB	4.5dB	99	48
(4,3) v=6 BCC	QPSK	16.5Mbps	3/2	7.0dB	5.2dB	88	42.7
(5,4) v=6 BCC	QPSK	17.6Mbps	8/5	7.7dB	5.5dB	82.5	40
(6,5) v=6 BCC	QPSK	18.3Mbps	5/3	6.4dB	5.6dB	79.2	38.4
(8,7) v=6 BCC	QPSK	19.2Mbps	14/8	5.1dB	5.7dB	75.4	36.6

PER versus Trms



PER, 64 Byte Packets, Primary (11Mbps) Rate, Multipath

- Trms = 25, 50, 100, 150, 200, 250, 350, 450, 550 ns



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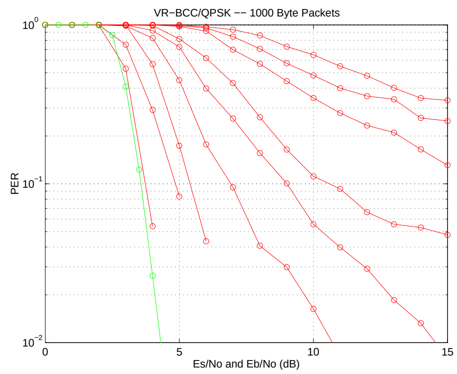
PER, 1000 Byte Packets, Primary (11Mbps) Rate, Multipath

- Trms = 25, 50, 100, 150, 200, 250, 350, 450, 550 ns



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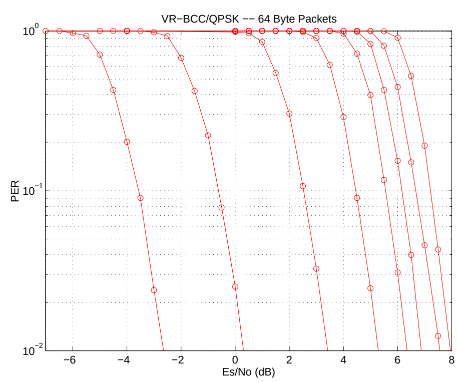
PER , 64 Byte Packets, Variable Rate, AWGN, Es/No



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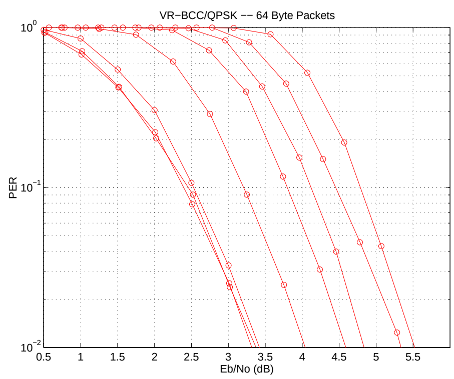
PER , 64 Byte Packets, Variable Rate, AWGN, Eb/No



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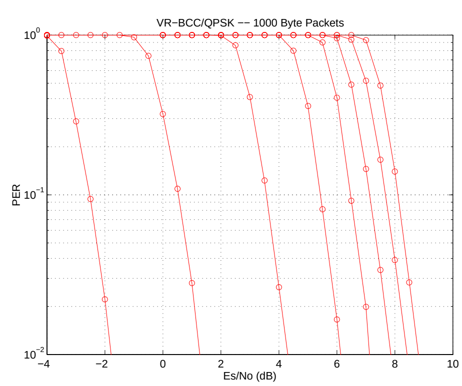
PER , 1000 Byte Packets, Variable Rate, AWGN, Es/No



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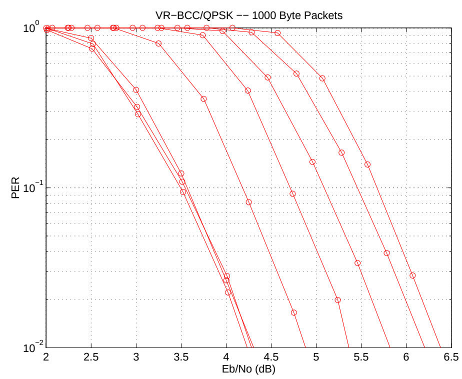
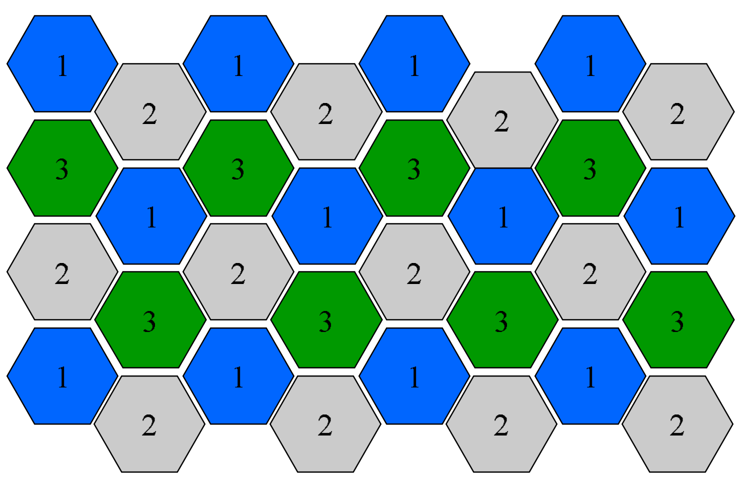
PER , 1000 Byte Packets, Variable Rate, AWGN, Eb/No



Cell Planning



Summary

- 64 state BCC
  - Coding Gain for Robust Performance
  - Variable Rate
  - Reasonable complexity
- Adaptive Equalizer
  - Robust multipath tolerance
  - Combines well with BCC
  - Reasonable complexity
- Backward Compatible
  - Realistic upgrade path
  - Uses existing RF/Antenna, MAC
- Ongoing HDL Design