Performance Analysis of Outer RS Coding Scheme

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Abstract

Outer Reed Solomon (RS) Code was proposed in [1] and further analyzed in [2].

The following results are based on simulator [2] analyzing the influence of different performance metrics, MCS, and channels:

- **PER/Throughput vs. E_b/N_0 or SNR:**
- **BPSK/QPSK/16-QAM/64-QAM and different coding rates**
- **AWGN, highway LoS and NLoS**

Results show that carful selection of performance metric needed to evaluate performance gains of novel schemes.

Introduction

Outer Reed Solomon (RS) code proposed in [1]:

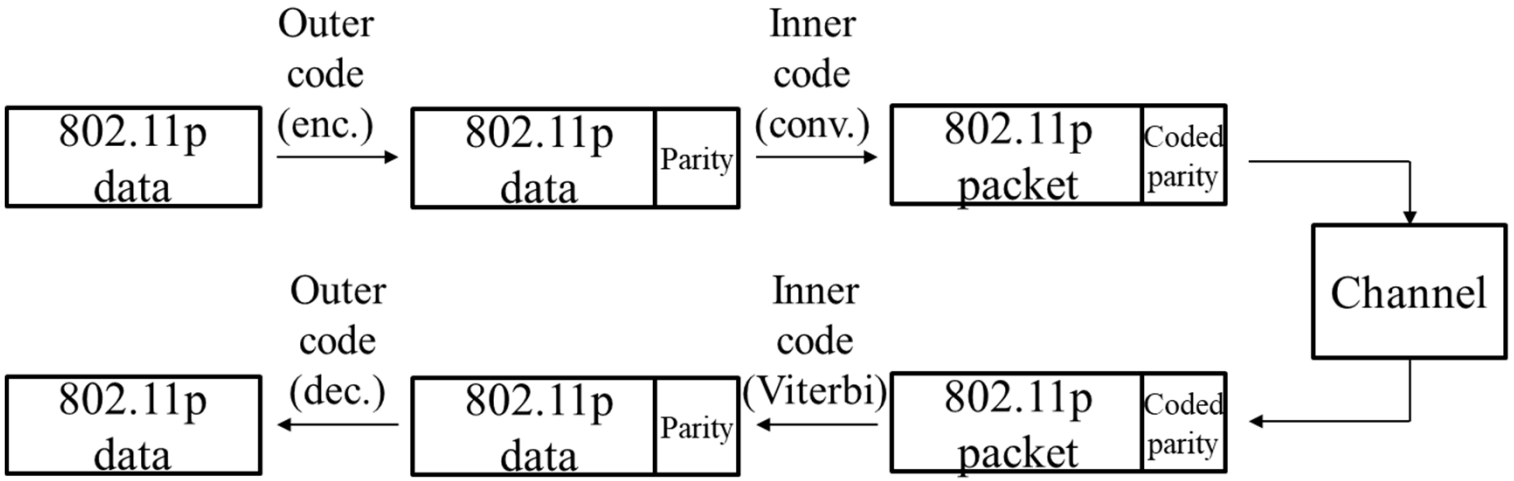


Fig. 1 – Reed Solomon outer coding (taken from [1])

Definitions

- **Signal-to-noise-ratio** $SNR = \frac{E_S}{N_0}$
- **Energy-per-bit-to-noise-ratio** $\frac{E_b}{N_0} = \frac{1}{\rho}\frac{E_S}{N_0}$

with spectral efficency $\rho = \frac{N_b N_{dspo}}{N_{dbps} N_{samp}}$

N_b **number of bits per packet**
N_{dbps} **number of data bits per OFDM symbol**
N_{dspo} **number of data symbols per OFDM symbol**
N_{samp} **number of complex samples per packet**

Definitions

- **Average Packet Error Rate** $PER = \frac{N_{Errors}}{N_{Packets}}$
- **Average Throughput** $TP = (1 - PER)\, N_b T_{Packet}$

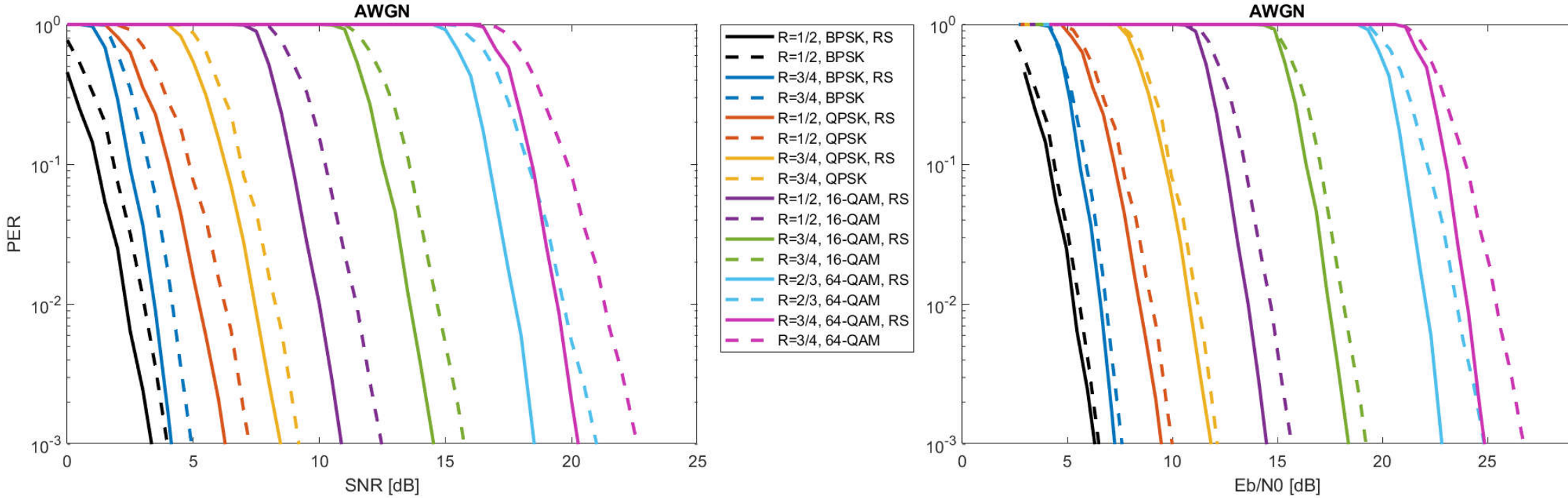
  packet duration $T_{Packet} = N_{Samp} T_{Samp} + T_{DIFS}$,
- **Note: Simulations stopped after 100 packet errors or 10^5 packets**

N_b number of bits per packet
N_{samp} number of complex samples per packet
T_{Samp} sampling period

Spectral Efficency for Different MCS

	R=1/2, BPSK	R=3/4, BPSK	R=1/2, QPSK	R=3/4, QPSK	R=1/2, 16-QAM	R=3/4, 16-QAM	R=2/3, 64-QAM	R=3/4, 64-QAM
ρ Outer RS coding scheme [dB]	-3.0	-3.1	-3.2	-3.4	-3.6	-3.9	-4.3	-4.6
ρ 802.11p [dB]	-2.5	-2.7	-2.8	-3.0	-3.2	-3.5	-3.9	-4.1
$\rho_{802.11p} - \rho_{RS}$	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.5

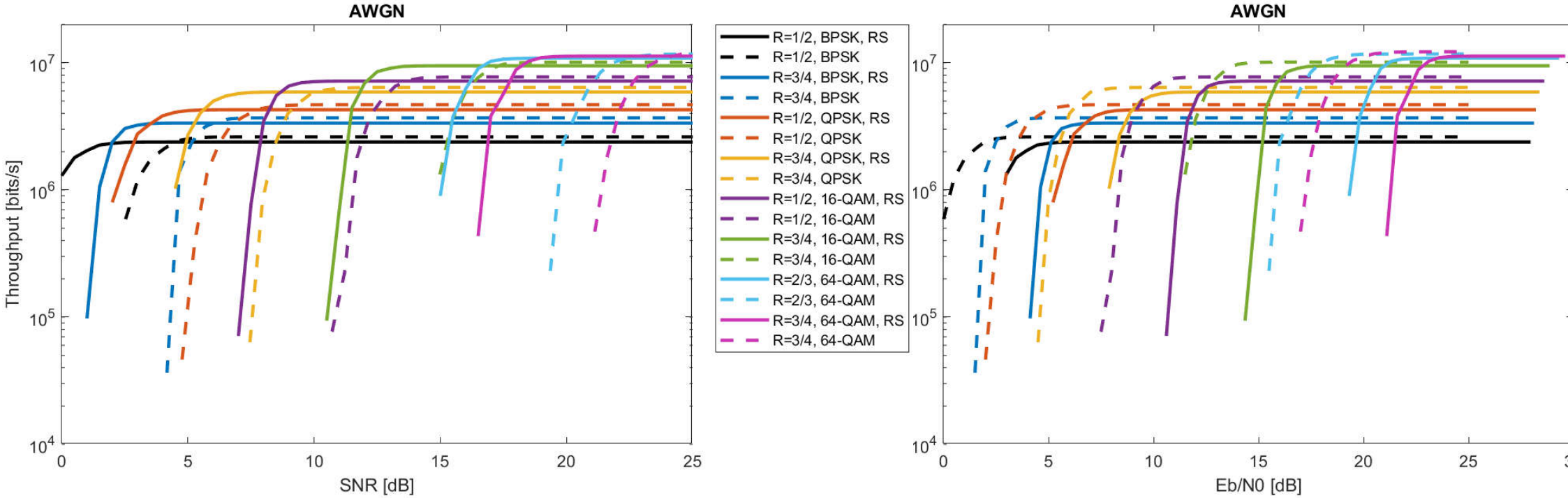
AWGN (1/2)



Comparison of PER in relation to SNR and E_b/N_0:

- PER vs. E_b/N_0 for fair comparison, accounts for additional energy on overhead
- Marginal gain for BPSK/QPSK/16-QAM, significant gain only for 64-QAM

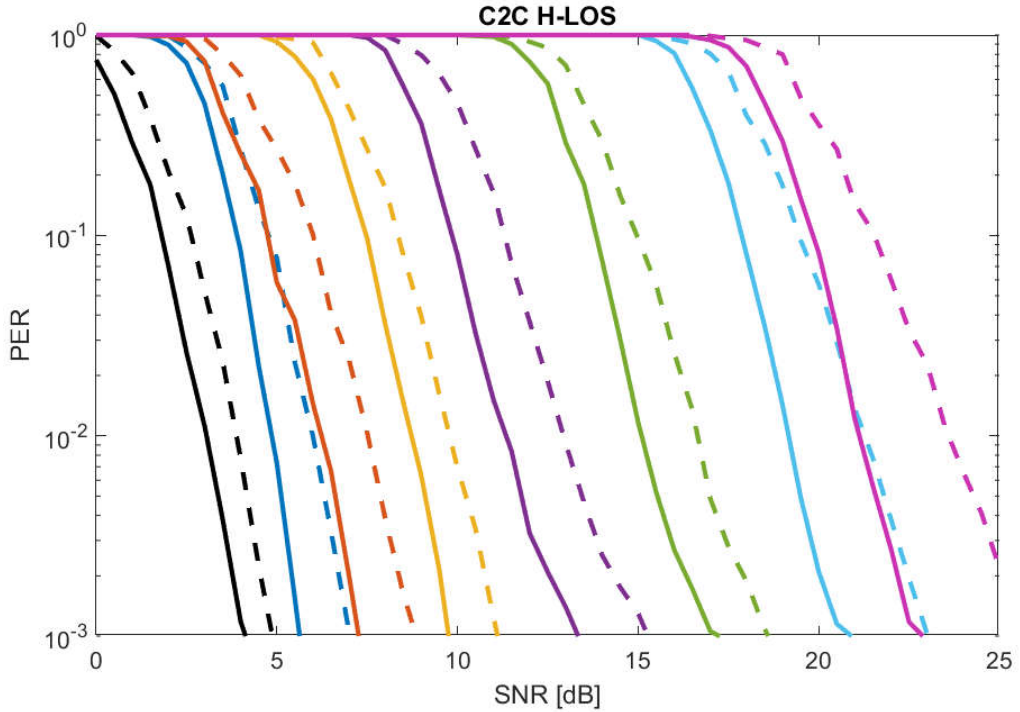
AWGN (2/2)

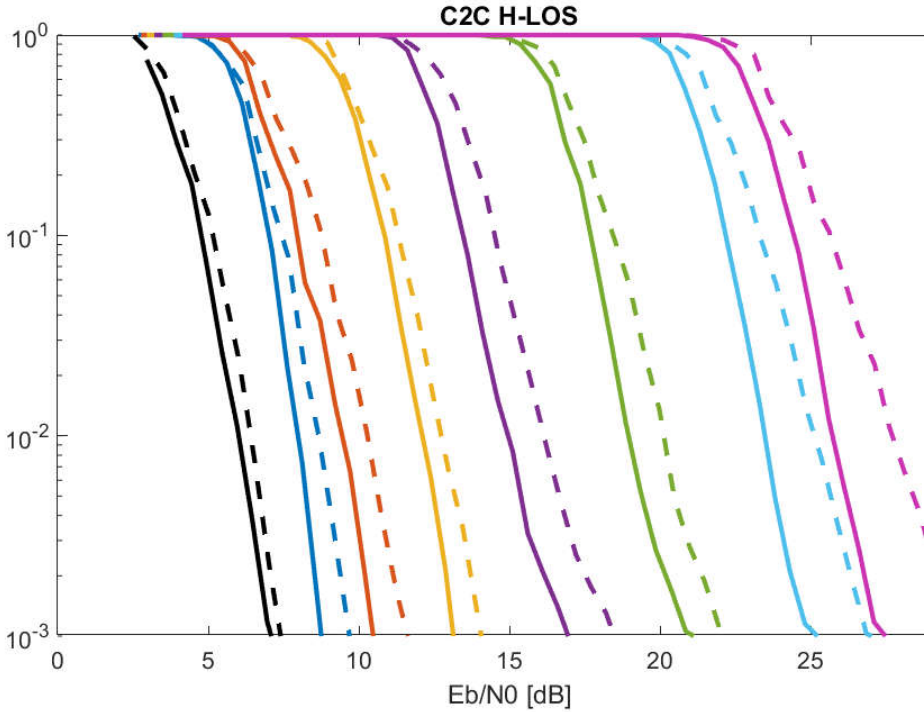


Comparison of throughput in relation to SNR and E_b/N_0:

- Throughput vs. E_b/N_0 for fair comparison, accounts for additional energy on overhead and channel use
- Outer RS coding scheme has lower throughput for all MCS and AWGN

Highway LoS (1/2)

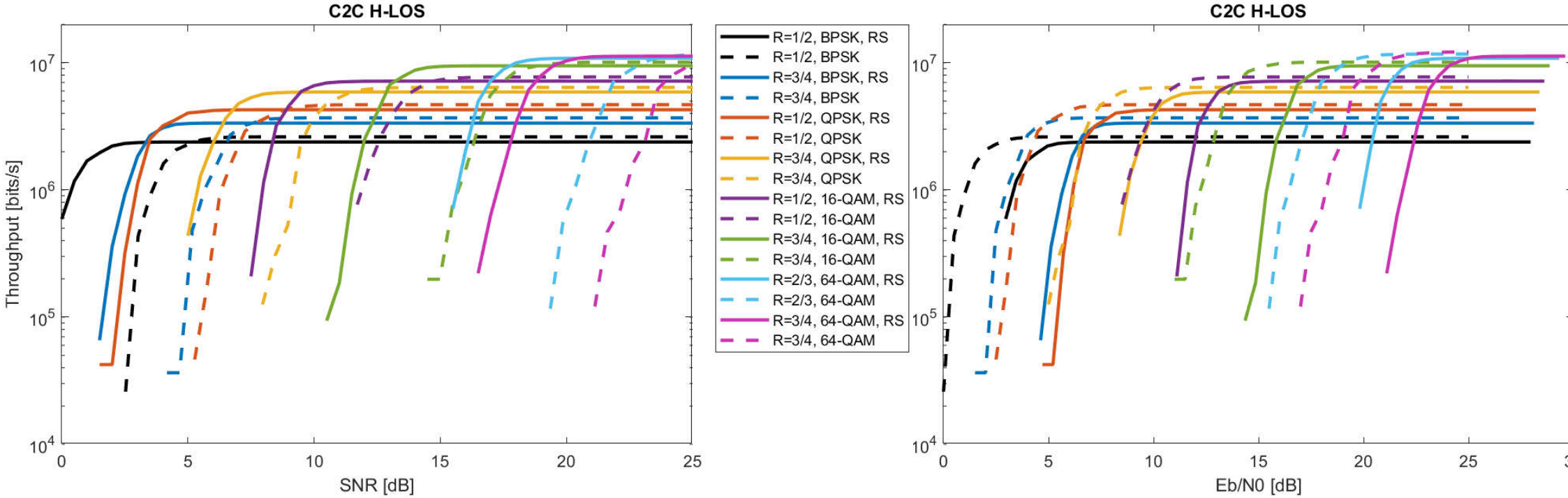




Comparison of PER in relation to SNR and E_b/N_0:

- **PER vs. E_b/N_0 for fair comparison, accounts for additional energy on overhead**
- **Marginal gain for BPSK/QPSK/16-QAM, significant gain only for 64-QAM**

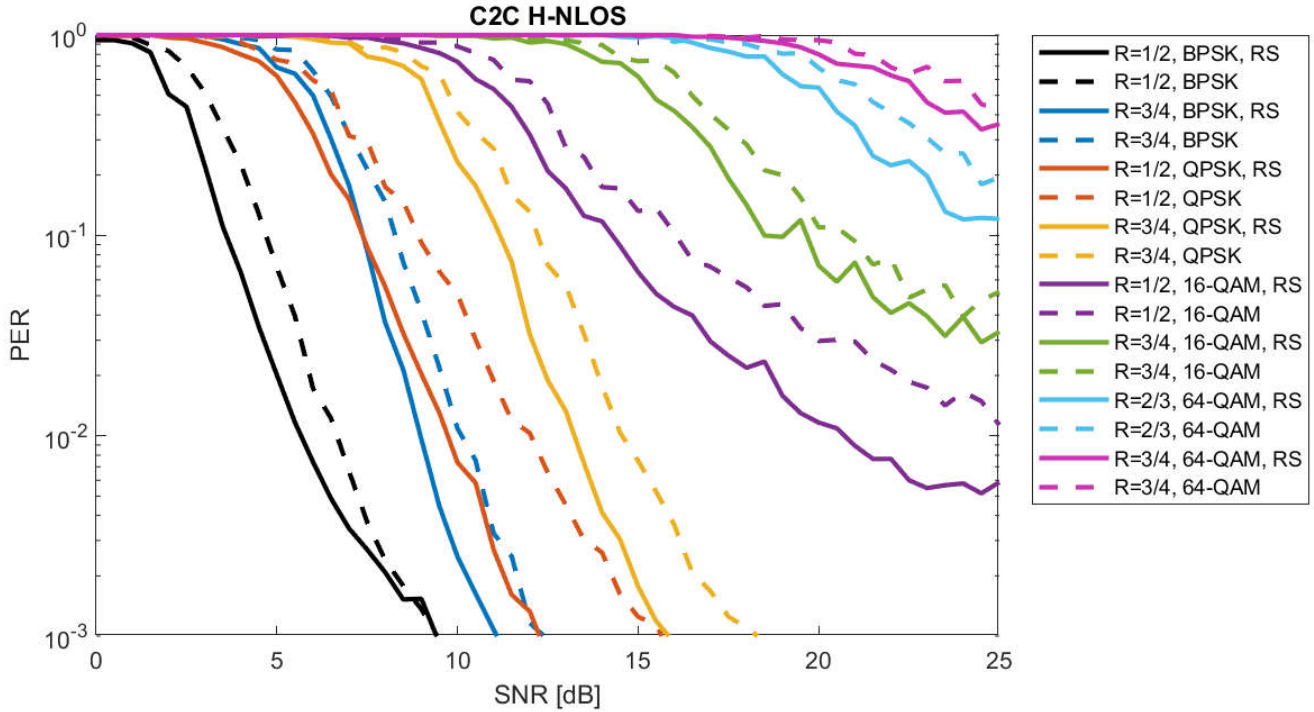
Highway LoS (2/2)

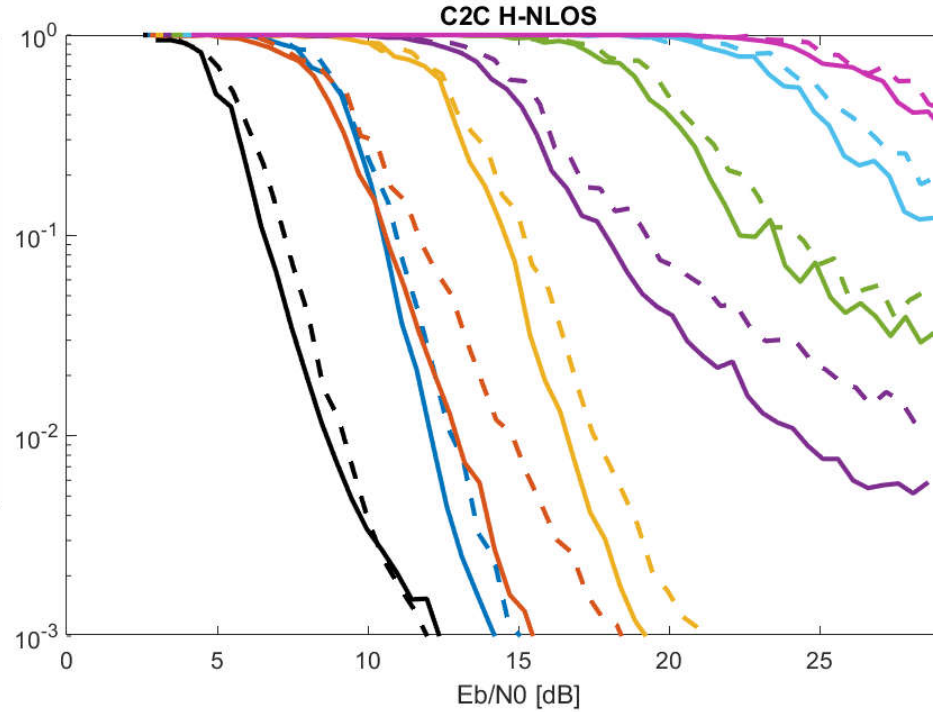


Comparison of throughput in relation to SNR and E_b/N_0:

- Throughput vs. E_b/N_0 for fair comparison, accounts for additional energy on overhead and channel use
- Outer RS coding scheme has lower throughput for all MCS and Highway LoS channel

Highway NLoS (1/2)

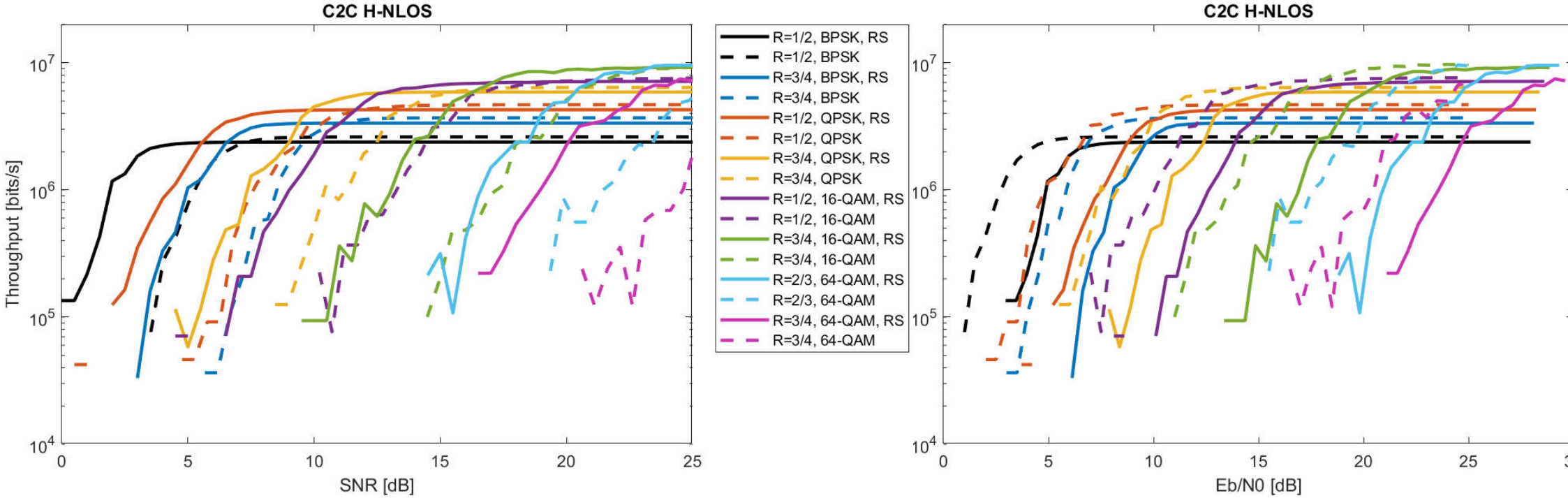




Comparison of PER in relation to SNR and E_b/N_0:

- PER vs. E_b/N_0 for fair comparison, accounts for additional energy on overhead
- Marginal gain for BPSK/QPSK(R=3/4), possibly significant gains for QPSK(R=1/2),16-QAM, 64-QAM

Highway NLoS (2/2)



Comparison of throughput in relation to SNR and E_b/N_0:

- Throughput vs. E_b/N_0 for fair comparison, accounts for additional energy on overhead and channel use
- Outer RS coding scheme has lower throughput for all MCS and Highway NLoS channel

Conclusions

- **PER vs. E_b/N_0 and PER vs. SNR:**
  - PER vs. E_b/N_0 for fair comparison: Accounts for additional energy on overhead
  - Marginal gains for outer RS coding scheme for BPSK/QPSK/16-QAM
  - Significant gain only for 64-QAM

- **Throughput vs. E_b/N_0 and Throughput vs. SNR:**
  - Throughput vs. E_b/N_0 for fair comparison:
    Accounts for additional energy on overhead and channel use
  - Outer RS coding scheme has lower throughput for all MCS and channels (AWGN, H-LoS, H-NLoS)

→ Careful selection of metric to evaluate performance gains of novel schemes

References

[1] O. Haran, “Backward compatible PHY feasibility,” IEEE 802.11-18/1214r0

[2] I. Sarris, "V2X Reed-Solomon Simulation Model," IEEE 802.11-18/1956r1.