Information Theory and Coding (CIE 425)

Project 5

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Objectives and implementation

1. Develop BER simulation tool for digital communication systems
2. System Model
3. Evaluate channel coding effectiveness

1. Python (NumPy, Matplotlib, Flask)
2. BPSK Modulation
3. Repetition Codes (1/3, 1/5)
4. **Hamming Codes (7,4) and (15,11)**
5. **Web-based GUI**

System Model

Information Bits → Channel Encoder → BPSK Modulator → Channel (AWGN/Rayleigh) → BPSK Demodulator → Channel Decoder → BER Calculation

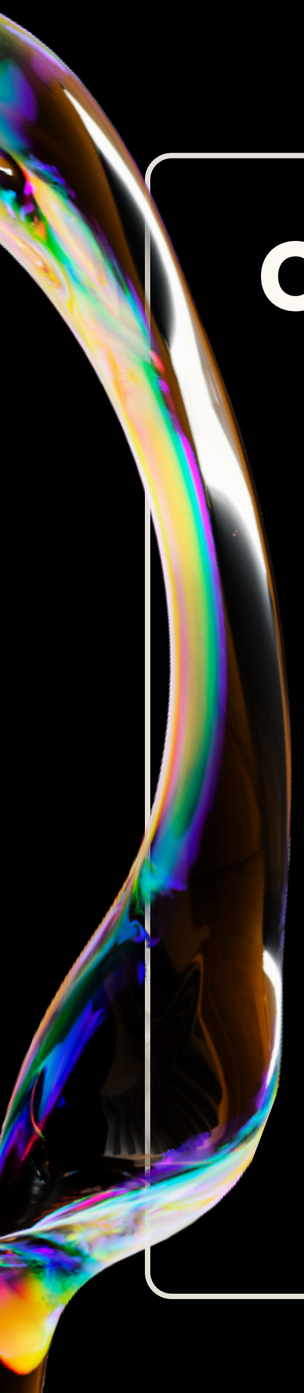
Key Components:

– BPSK: 0→-1, 1→+1

- AWGN: Additive white Gaussian noise

- Rayleigh: Multipath fading, r = h·s + n

- BER = Number of errors / Total bits

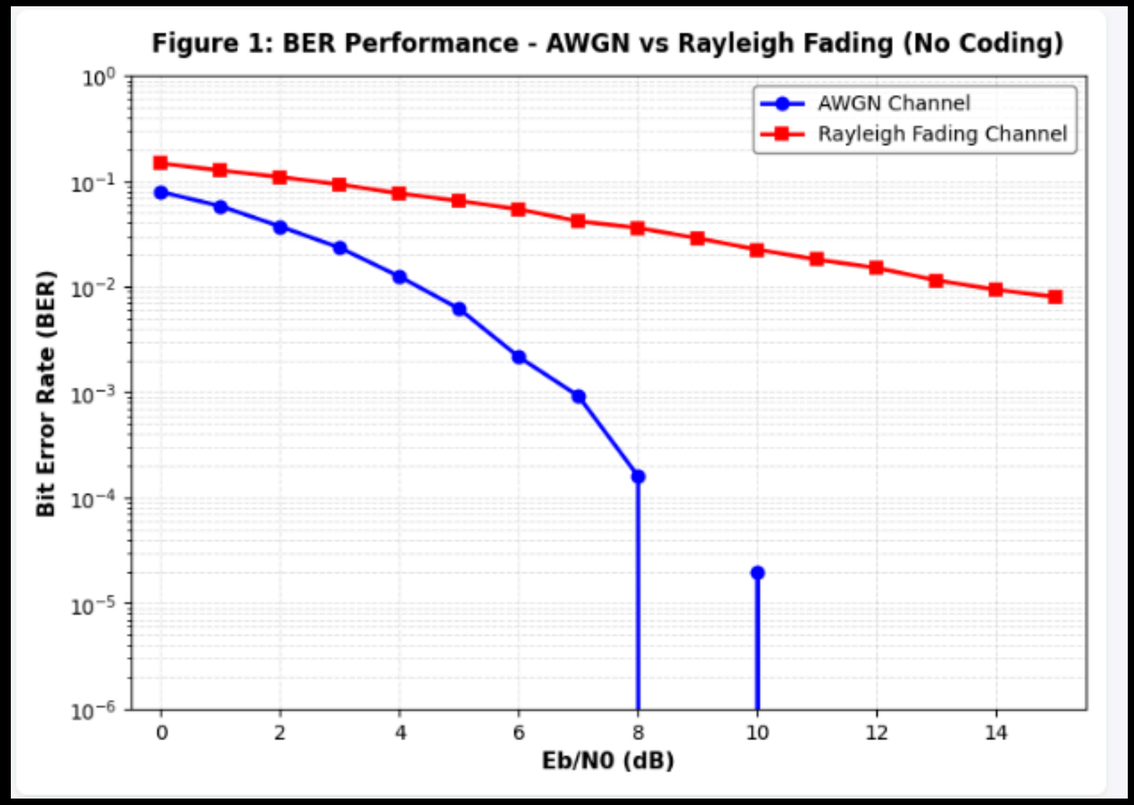


CHANNEL CODING SCHEMES

Repetition Codes:
- Each bit repeated n times (n=3 or 5)
- Code rates: 1/3, 1/5
- Decoding: Majority voting
- Simple but bandwidth-inefficient

Hamming Codes:
- (7,4): 4 info bits → 7 coded bits, Rate = 4/7
- (15,11): 11 info bits → 15 coded bits, Rate = 11/15
- Single error correction capability
- Efficient: Better rate with good error correction

RESULTS – AWGN VS RAYLEIGH



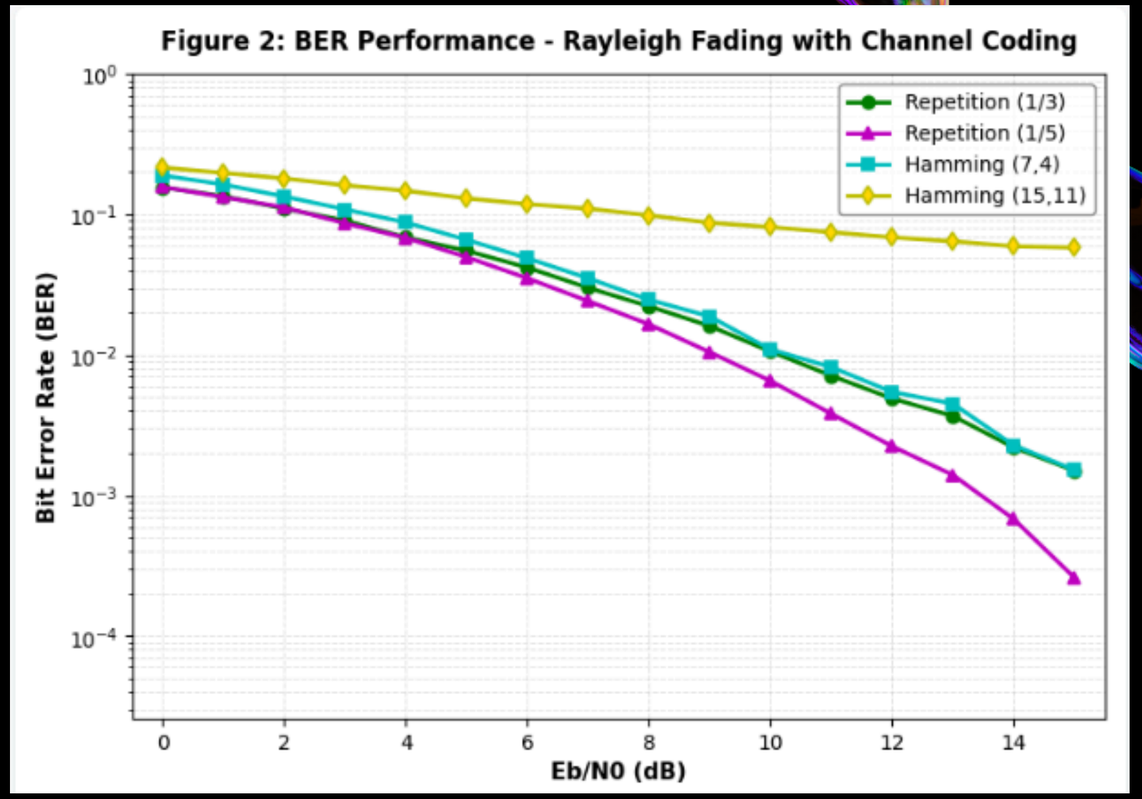
Key Findings:

- AWGN shows exponential BER improvement
- Rayleigh severely degraded by fading
- At 10 dB Eb/N0:
    - AWGN: 2×10^{-5}
    - Rayleigh: 2.25×10^{-2}
    - 600× performance difference!

RESULTS – CODED SYSTEMS

Performance at 10 dB:

- Repetition (1/5): 6.54×10^{-3} (Best)
- Hamming (15,11): 8.132×10^{-2}
- Hamming (7,4): 1.09×10^{-2}
- Repetition (1/3): 1.06×10^{-2}



SLIDE 9: PERFORMANCE SUMMARY

Summary: BER at 10 dB

System	BER @ 10dB	Code Rate
AWGN (No Coding)	2.000000e-05	1
Hamming (15,11)	8.132813e-02	11/15
Hamming (7,4)	1.094000e-02	4/7
Rayleigh (No Coding)	2.250000e-02	1
Repetition (1/3)	1.060000e-02	1/3
Repetition (1/5)	6.540000e-03	1/5

TRADE-OFF ANALYSIS

High Code Rate (11/15):
✓ Better bandwidth efficiency
✓ Higher data rate
✗ Less error protection

Low Code Rate (1/5):
✓ Excellent error correction
✓ Works in poor channels
✗ Lower data rate

GUI FEATURES

User Configurations:
- SNR Range: Min, Max, Step
- Channel: AWGN or Rayleigh
- Coding: Enable/Disable (Rayleigh only)
- Code Selection: Repetition (n=3,5) or Hamming (m=3,4)

Outputs:
✓ Single simulation mode
✓ Generate all 3 figures automatically
✓ Real-time BER plots
✓ Performance summary table

THANK YOU