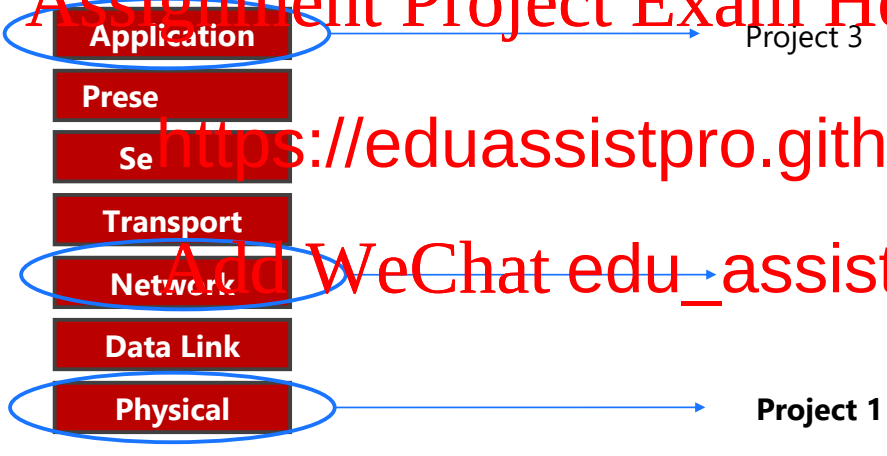
Recitation 1: Exploring the Layer

FEBA
Atul Ba

Open Systems Interconnection Model

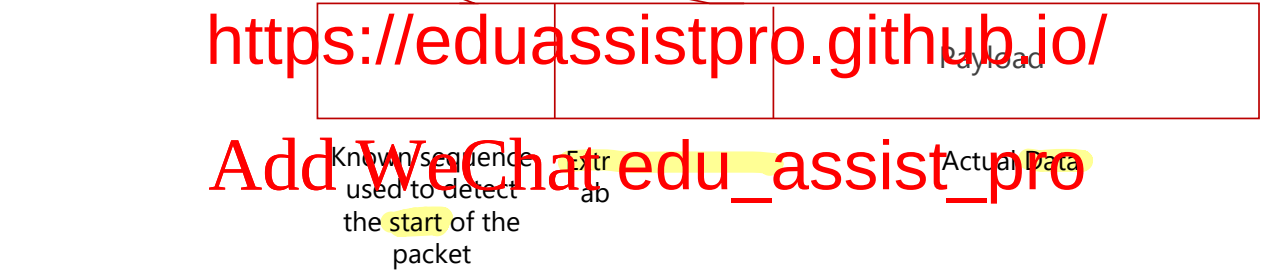


Project 1: Physical Layer(WiFi)

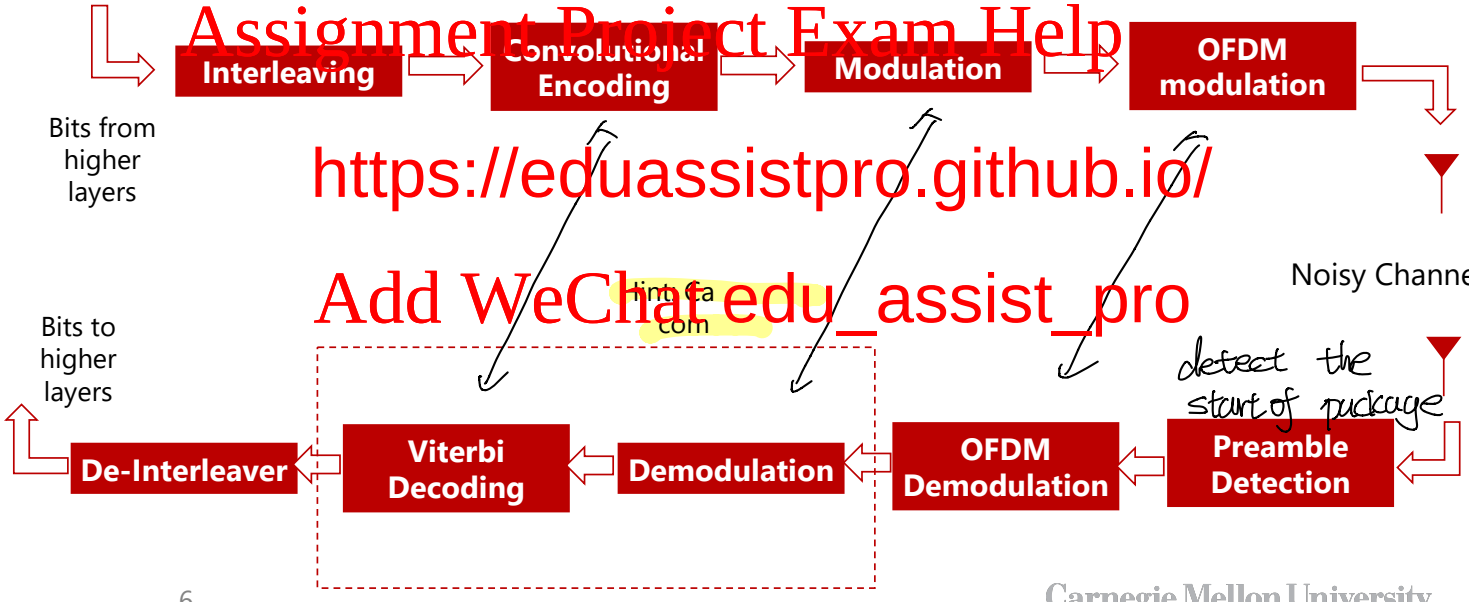
https://eduassistpro.github.io/

Add WeChat edu_assist_pro

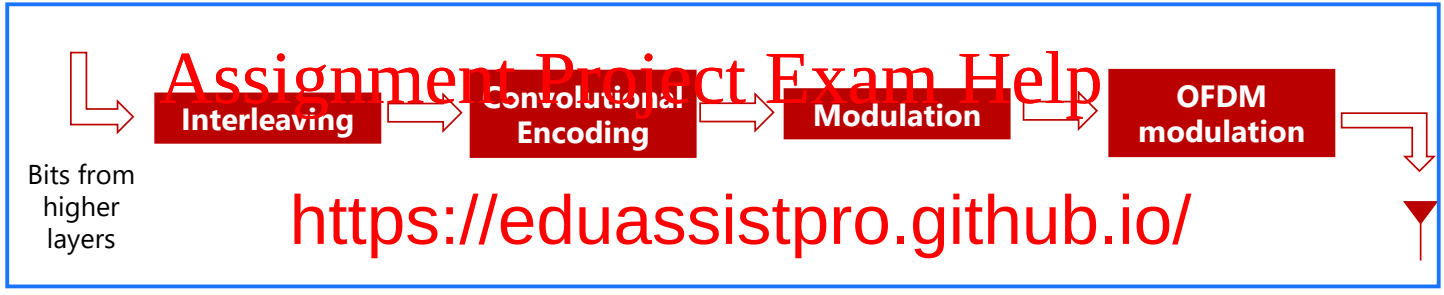
WiFi Packet

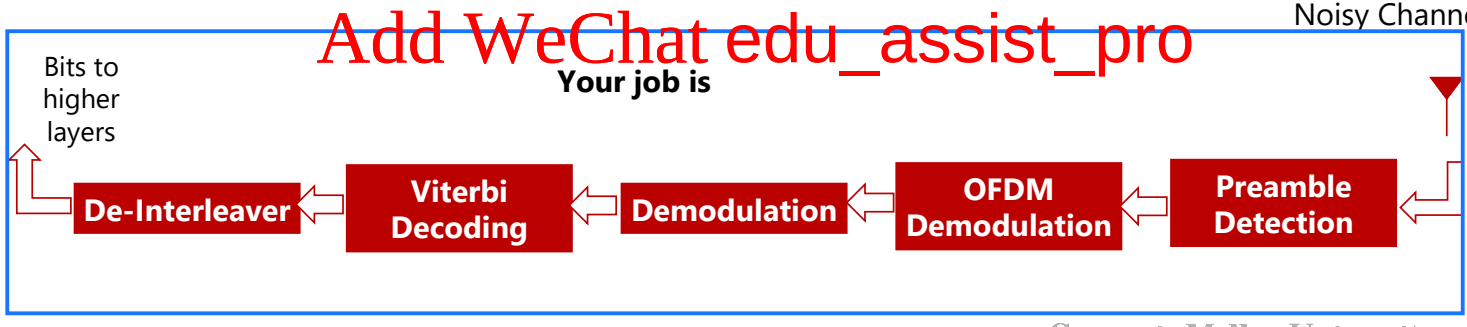


How WiFi packets are created?



How WiFi packets are created?





Level 1: Interleaving

Input bits are rearranged by a well-known permutation pattern

Interleaver: Rows = 2, Columns = 3

example:

Resilient to burst errors

Level 2: Convolutional Coding

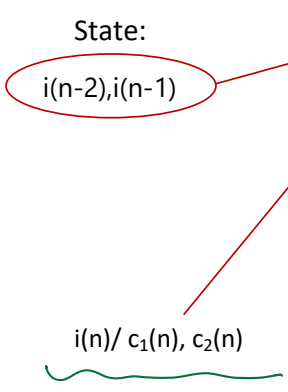
Encode the input bits using a 'special' polynomial to add redundancy.

For this project, we use a 1/2 rate encoder with G(7,5) generator polynomial

Input Bits: i(n), i(n-1), i(n-2)

Output Bits: $c_1(n)$ = i(n) xor i(n-1) xor i(n-2)

$c_2(n)$ = i(n) xor i(n-2)



example when t=1 i(n-2), i(n-1) = 0, 0

i(n) = 1

Then $c_1 = 1 \text{ xor } 0 \text{ xor } 0 = 1$

$c_2 = 1 \text{ xor } 0 = 1$

∴ output = 11

⇓

when t=2

i(n-2) = 0

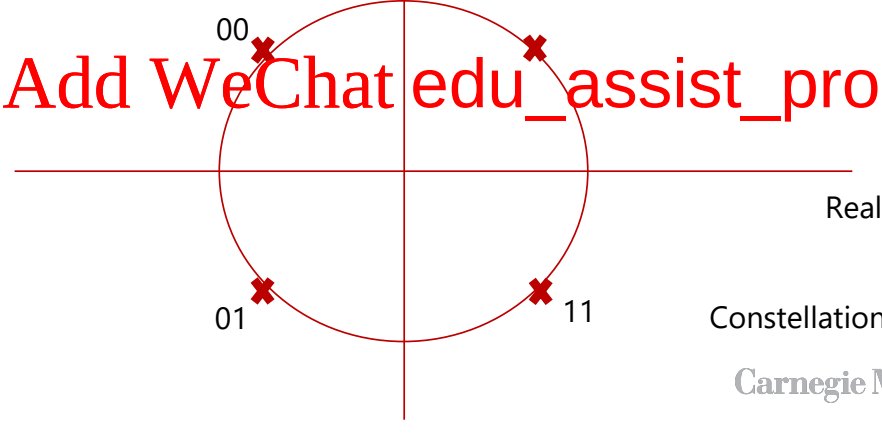
i(n-1) = 1

Level 3: Modulation

Coded Bits to Symbol Mapping: BPSK, QPSK, 4-QAM

Conveying information by changing the signal and represent them in complex domain.

We use 4-Q



Constellation Diagram

Level 4: Orthogonal Frequency Division Multiplexing (OFDM)

Divide the available bandwidth into multiple orthogonal subcarriers

Some excellent properties: spectral efficiency, robustness to fading and inter-symbol interference

Implemented using IFFT

Level 5: Padding and Noise

Random number of padding bits are added before and after the information symbols

Used to mo

Detect begi

Beginning: Preamble
End: ??

↑ Need to implement

Viterbi Decoding

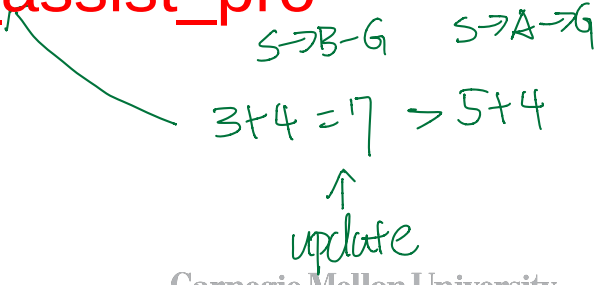
Used at WiFi receivers for inverse of convolutional coding

Before th

Find shortest distance from S to D?

Use Dynamic Programming/Dijkstra's algorithm

try to check distance, No update since 4+1=5>3



Shortest path from S to D: S-C-B-G-D

Looks similar

No signal at start

Starting Node = '00' state

Destination node 'D' = any rightmost state

Adjacent node distance = branch metric

Received symbols: z_0,z_1,z_2,z_3,z_4

Code symbols: x_0,x_1,x_2,x_3,x_4

Branch metric = $|z_0 - x_0|^2 + |z_1 - x_1|^2$
and so on...

Viterbi Decoding (contd.)

Step 1: Prepare Trellis

Viterbi Decoding (contd.)

This model look different for QAM Modulation!

Step 2: Label using symbols x_k(BPSK modulation)

- For BPSK symbols are (1, -1)
- In project 1, values are different

Input bits/BPSK symbols

Viterbi Decoding (contd.)

Step 3: Received sequency z_k

Received Sequence: $(z_0,z_1,z_2,z_3,z_4,z_5,z_6,z_7,z_8,z_9)$

= (0.8 + 0.4j , 0.8 - j, -1.4 + 0.1j , 1.2 - 0.2j, -0.4 + 0.2j, 1.5 + 0.7j , -1.3 + 0.2j , -0.5 -0.1j, 1.3 + 0.1j, -1.8-0.3j)

Viterbi Decoding (contd.)

Step 4: Calculate all branch metrics

Viterbi Decoding (contd.)

Branch metric calculation

$(x_4 , x_5) = (-1 , 1)$

$(z_4 , z_5) = (-0.4 + 0.2j , 1.5 + 0.7j)$

Branch metric = $|z_4 - x_4|^2 + |z_5 - x_5|^2 = 1.14$

Viterbi Decoding (contd.)

Step 5: Find cost of reaching t=5 for all states with 00 as starting state S

Starting state 'S'

Viterbi Decoding (contd.)

Step 5: Find cost of reaching t=5 for all states with 00 as starting state S

Viterbi Decoding (contd.)

Step 5: Find cost of reaching t=5 for all states with 00 as starting state S

Least cost final state

Viterbi Decoding (contd.)

Step 6: Traceback to find shortest path

Least cost final state

Viterbi Decoding (contd.)

Step 7: Use Trellis with bits to get decoded bits

1 1 0 1 0

Input bit sequence estimate is 1 1 0 1 0

Closing Comments

- You are welcome to use any signal processing libraries except for turbo code decoding libraries
- Deliverabl
  - MATLAB s
  - Design rep
- Don't submit executable files
- Due date: Feb 28, 11.59 pm EDT