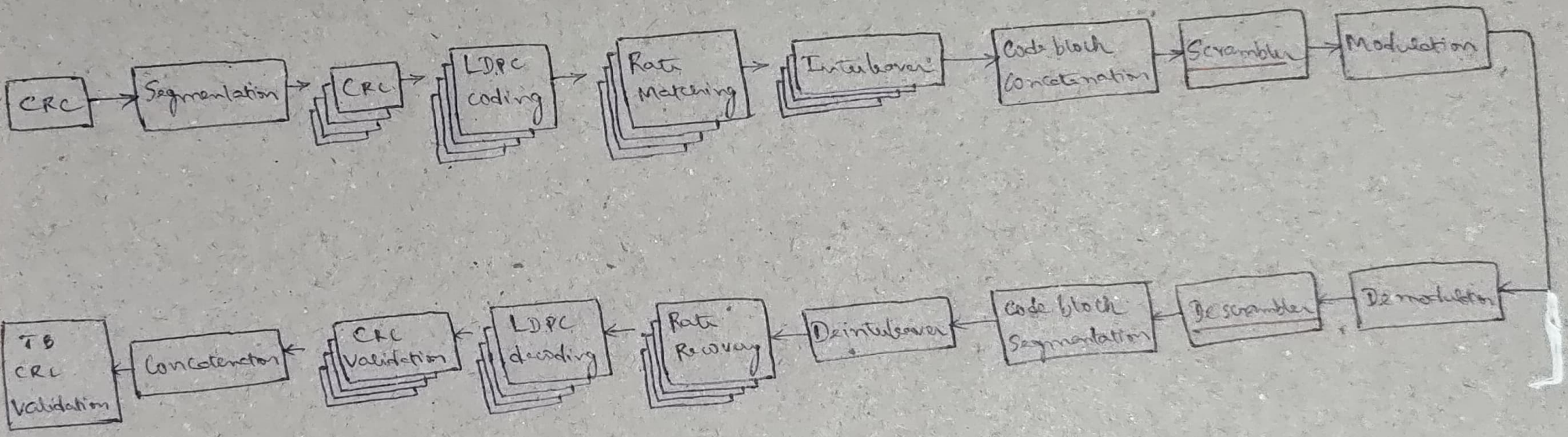
5G Transmit and receive chain upto Scrambler



Scrambling Principles

- Consider a concatenated block of G interleaved bits $b(0), \ldots, b(G-1)$
- Scrambled bits $\tilde{b}(0), \ldots, \tilde{b}(G-1)$ are given as

$$\tilde{b}(i) = b(i) \oplus c(i), \quad i = 0, \ldots, (G-1)$$

- $c(i)$ is pseudo random sequence
- Example:

  8-bit coded sequence $b = [0\,0\,0\,0\,0\,0\,0\,0]$ and

  $c = [0\,1\,1\,0\,1\,0\,0\,1]$

  $\tilde{b}(i) = [0\,1\,1\,0\,1\,0\,0\,1]$

- Scrambling is done to randomize the output of interleaver
  - both inner and outer signal points in the 16/64/256 QAM constellation to be used.

De-scrambling principles.

- For block of bits $b(0), \ldots, b(G-1)$, where G is the number of bits in code word.
- Received scrambled bits $\tilde{b}(0), \ldots, \tilde{b}(G-1)$ were calculated as

$$\tilde{b}(i) = b(i) \oplus c(i), \quad i = 0, \ldots, (G-1).$$

- Received descrambled bits $\tilde{b}(0), \ldots, \tilde{b}(G-1)$ can be recovered as

$$b(i) = \tilde{b}(i) \oplus c(i), \quad i = 0, \ldots, (G-1),$$

- Example:

8-bit coded sequence $b = [0\,0\,0\,0\,0\,0\,0\,0]$ and

$c = [0\,1\,1\,0\,1\,0\,0\,1]$

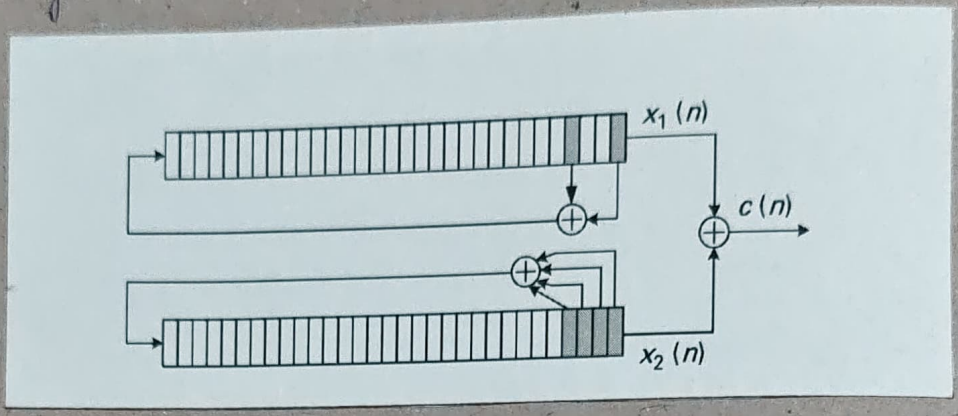
$\tilde{b}(i) = [0\,1\,1\,0\,1\,0\,0\,1]$

$b(i) = \tilde{b}(i) \oplus c(i) = [0\,0\,0\,0\,0\,0\,0\,0]$

Pseudo random sequence generation in 5G

(Sec: 5.2 of 38.211)

⊙ Pseudo random sequences in 5G are defined by a length-31 Gold sequence



⊙ Output sequence $c(n)$ of length G where $n = 0, 1, \ldots, G-1$

$$c(n) = x_1(n) \oplus x_2(n)$$

$$x_1(n+31) = x_1(n+3) \oplus x_1(n)$$

$$x_2(n+31) = x_2(n+3) \oplus x_2(n+2) \oplus x_2(n+1) \oplus x_2(n)$$

⊙ Standard, reject first 1600 samples and uses $c'(n) = c(n+1600)$ instead)

⊙ First sequence $x_1(n)$ is initialized as

$$x_1(n) = 1 \quad , n = 0$$
$$= 0 \quad , 0 < n \leq 30$$

⊙ Second sequence $x_2(n)$ is initialized by writing a constant C_{init} in binary form.

⊙ C_{init} is determined based on a Cell ID and RNTI.

Eg: Consider $C_{init} = 255$

Second sequence $x_2(n)$

$$x_2(n) = 1 \quad , n \leq 7$$
$$= 0 \quad , 7 < n \leq 30$$