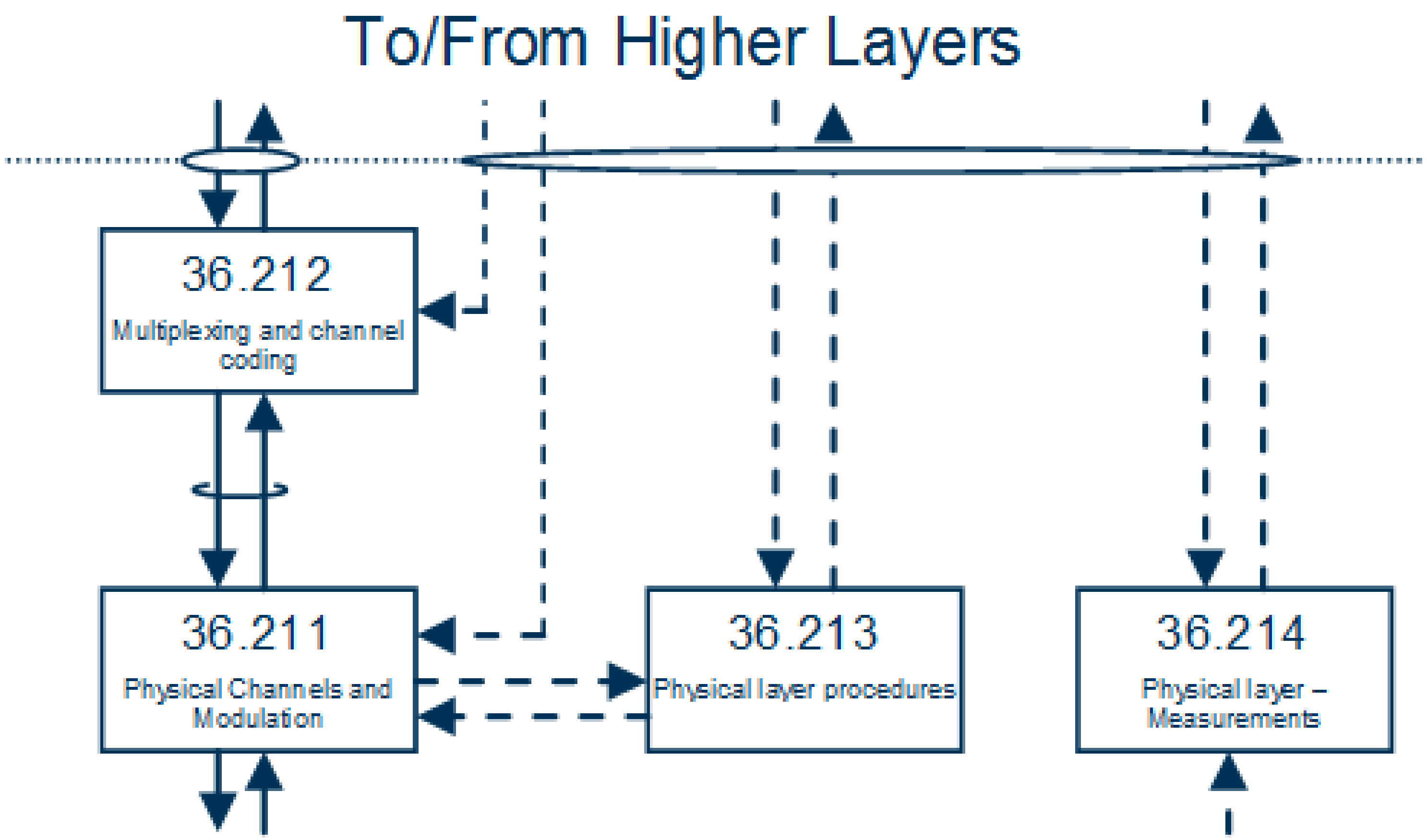
LTE PHY description
Link Level Simulator

Erika Almeida
Lilian Freitas

INDT
Natural Partner for Innovation

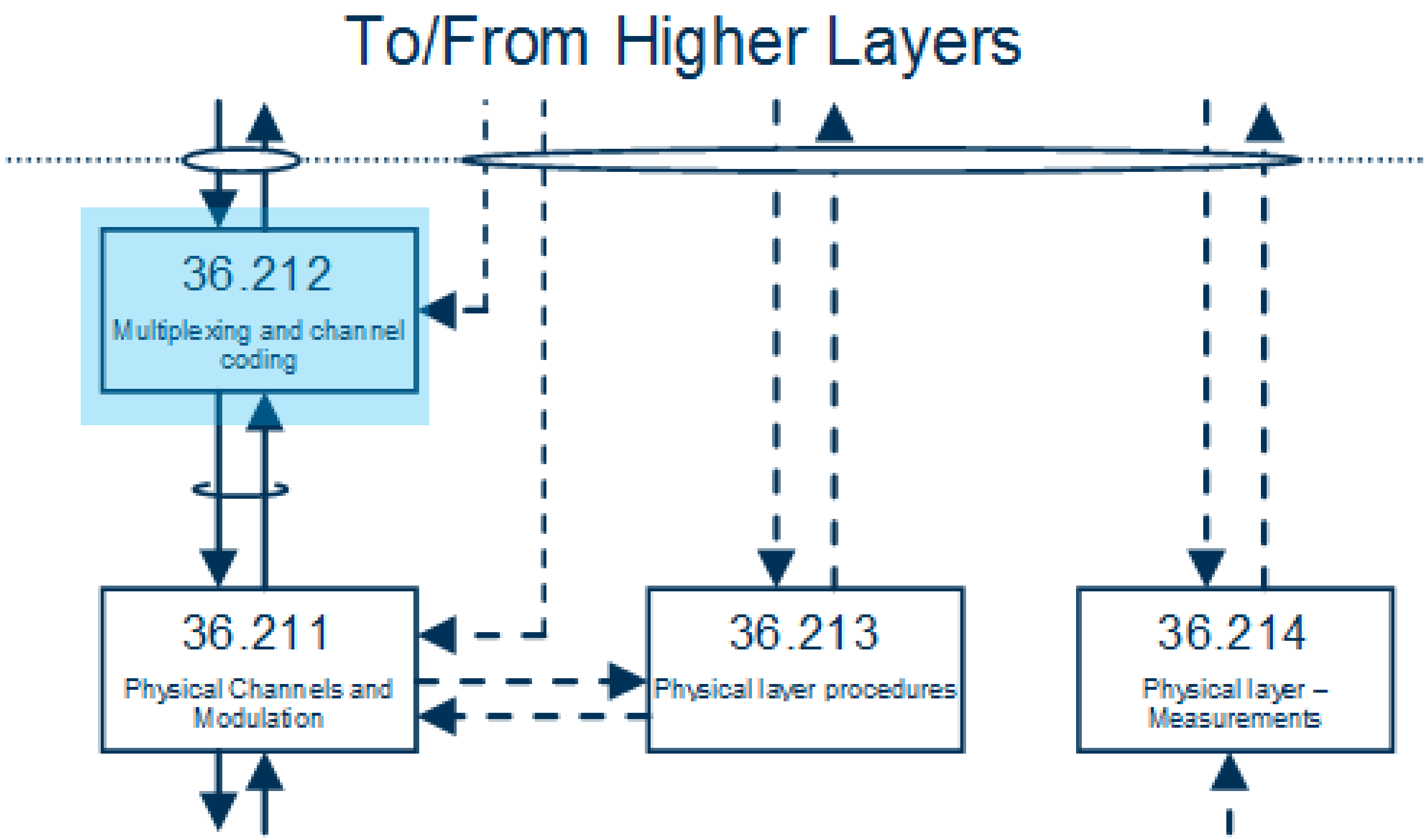
Summary

- Physical layer documents
- from TS 36.201



TS 36.212 – Multiplexing and Channel Coding

Multiplexing and Channel Coding



Transport block processing (downlink)

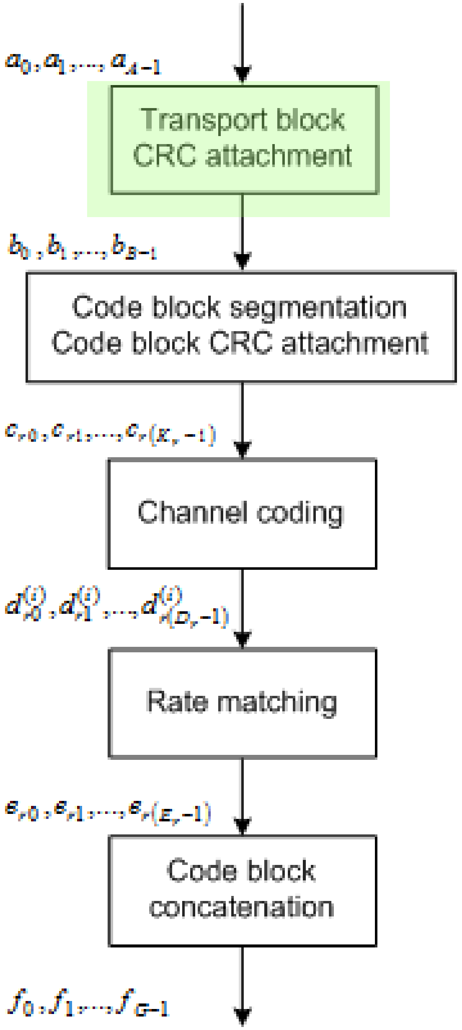


Figure 5.3.2-1: Transport block processing for DL-SCH, PCH and MCH.

CRC Calculation

- Input bits $a_0, a_1, \ldots, a_{A-1}$, where A is the size of input sequence
- Parity bits $p_0, p_1, \ldots, p_{L-1}$, where L is the number of parity bits
- The parity bits are generated by one of the following cyclic generator polynomials:
  - $g_{CRC24A}(D) = [D^{24} + D^{23} + D^{18} + D^{17} + D^{14} + D^{11} + D^{10} + D^{7} + D^{6} + D^{5} + D^{4} + D^{3} + D + 1]$ and;
  - $g_{CRC24B}(D) = [D^{24} + D^{23} + D^{6} + D^{5} + D + 1]$ for a CRC length $L = 24$ and;
  - $g_{CRC16}(D) = [D^{16} + D^{12} + D^{5} + 1]$ for a CRC length $L = 16$.
  - $g_{CRC8}(D) = [D^{8} + D^{7} + D^{4} + D^{3} + D + 1]$ for a CRC length of $L = 8$.
- The use of one polynomial or another depends on the type of channel. In this simulator we will simulate only PDSCH.

CRC Calculation - PDSCH

- Input bits $a_0, a_1, \ldots, a_{A-1}$, where A is the size of input sequence
- Parity bits $p_0, p_1, \ldots, p_{L-1}$, where L is the number of parity bits
- The encoding is performed in a systematic form (the input data is embedded in the output data):

$$a_0 D^{A+23} + a_1 D^{A+22} + \ldots + a_{A-1} D^{24} + p_0 D^{23} + p_1 D^{22} + \ldots + p_{22} D^1 + p_{23}$$

- The bits after CRC attachment are denoted by: $b_0, b_1, \ldots, b_{B-1}$, where B = A + L. The relationship between a_k and b_k is:
- $b_k = a_k, for\ k = 0, 1, 2, \ldots., A-1$
- $b_k = p_k, for\ k = A, A+1, \ldots, A+L-1$

Transport block processing (downlink)

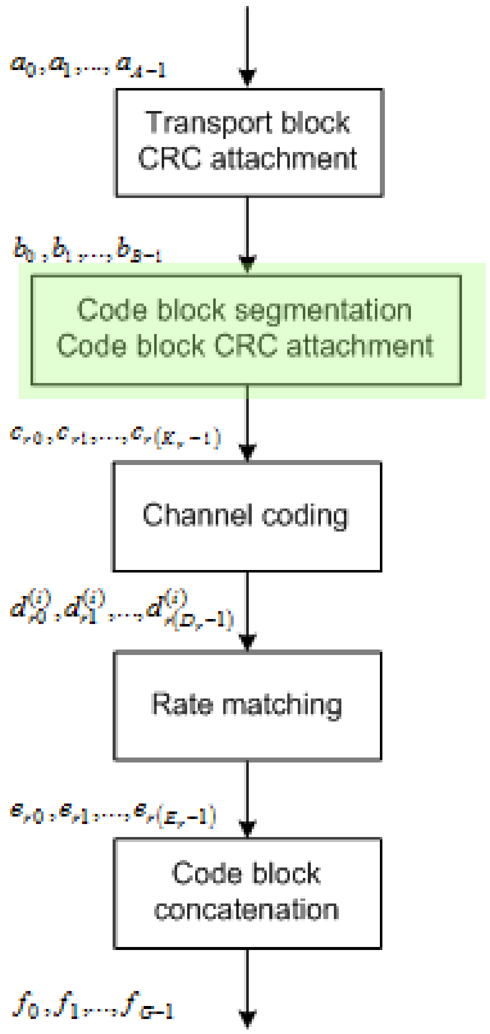


Figure 5.3.2-1: Transport block processing for DL-SCH, PCH and MCH.

Code block segmentation and code block CRC attachment

- The maximum code block size is: $Z = 6144$
- If $B \geq Z$, segmentation is performed and an additional CRC sequence of L = 24 is attached to each code block. Generator polynomial $g_{CRC24B}(D)$ is used in this case.

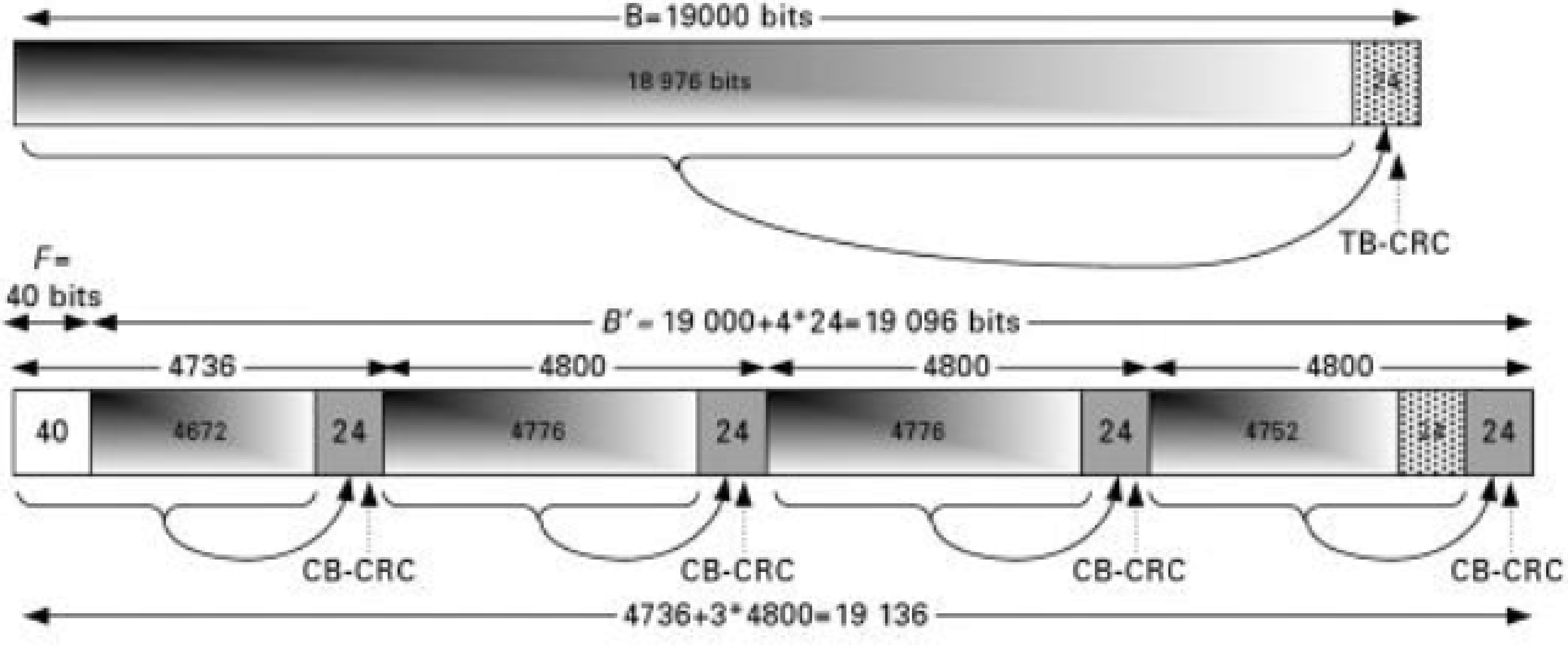


Figure 11.11. An example of codeblock segmentation.

- The bits output from code block segmentation are denoted by: $c_{r0}, c_{r1}, \ldots, , c_r(k_r) - 1$
- r is the code block number
- K_r is the number of bits for the code block r.

- Segmentation is described in clause 5.1.2 of TS 36.212
- A very nice description is shown on this link.

Transport block processing (downlink)

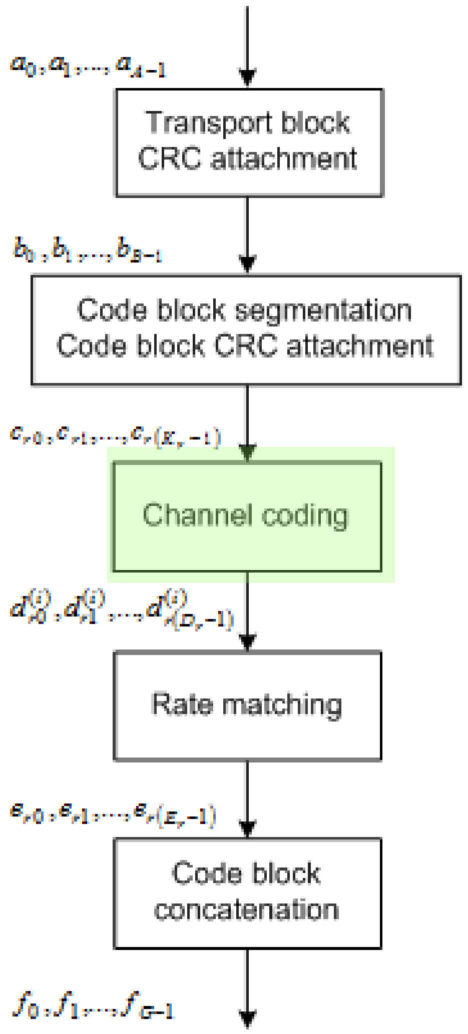


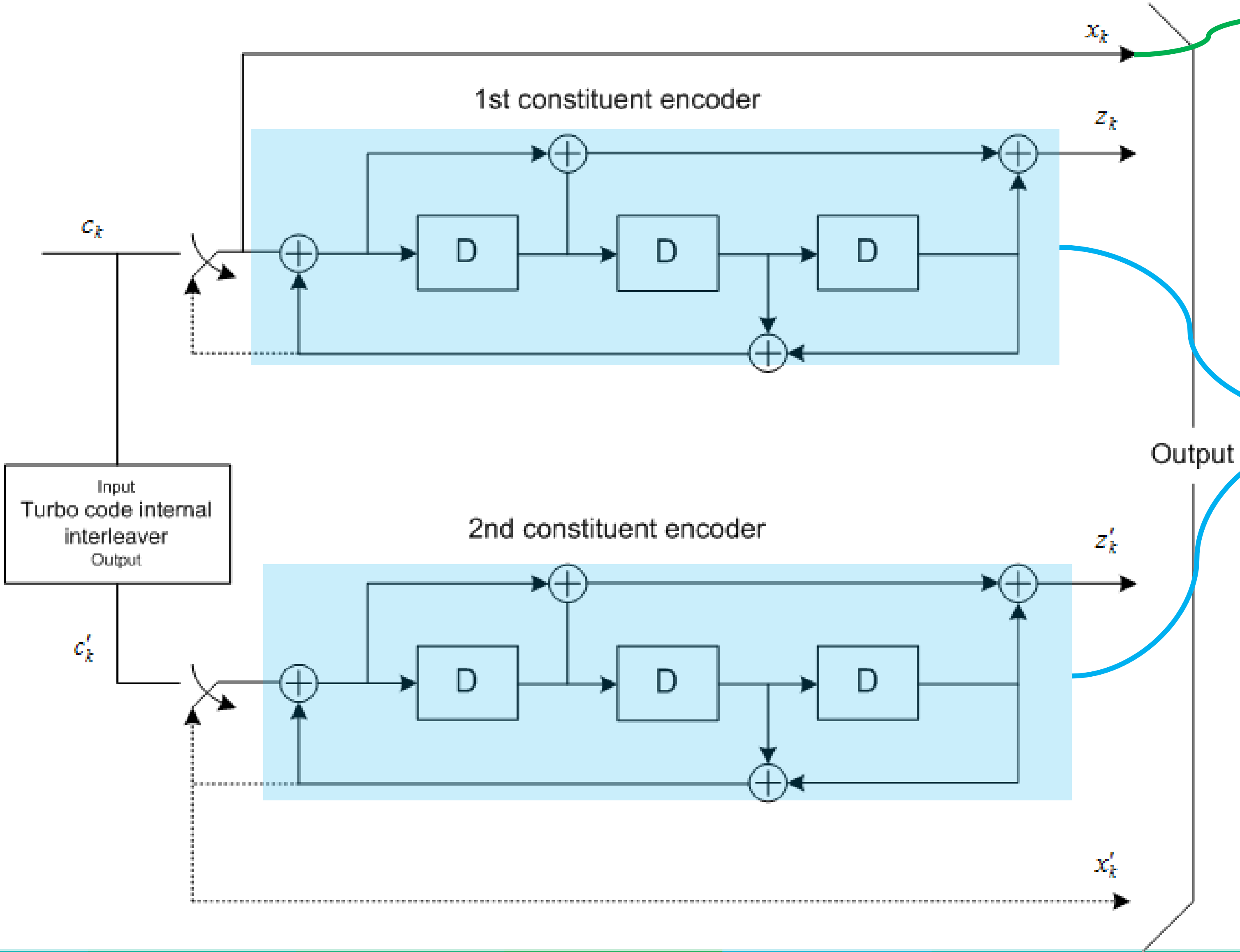
Figure 5.3.2-1: Transport block processing for DL-SCH, PCH and MCH.

Channel Coding (general information)

- Channel coding can be divided in two methods:
  - Backward error correction (BEC): provides only error detection
  - Forward error correction (FEC): provides error detection and correction - ↓ retransmissions.
- Codes can be:
  - Systematic: the input bits appear on the output
  - Nonsystematic: the input bits do not appear on the output
- Important feature:
  - Code weight: number of “non-zero” symbols in the code word – high weight code words can be distinguished easier.

Turbo Coding (5.1.3.2)

-



Systematic output:

presents a copy of input bits.

Constituent Encoders:

Both encoders are equal

Channel Coding (5.1.3)

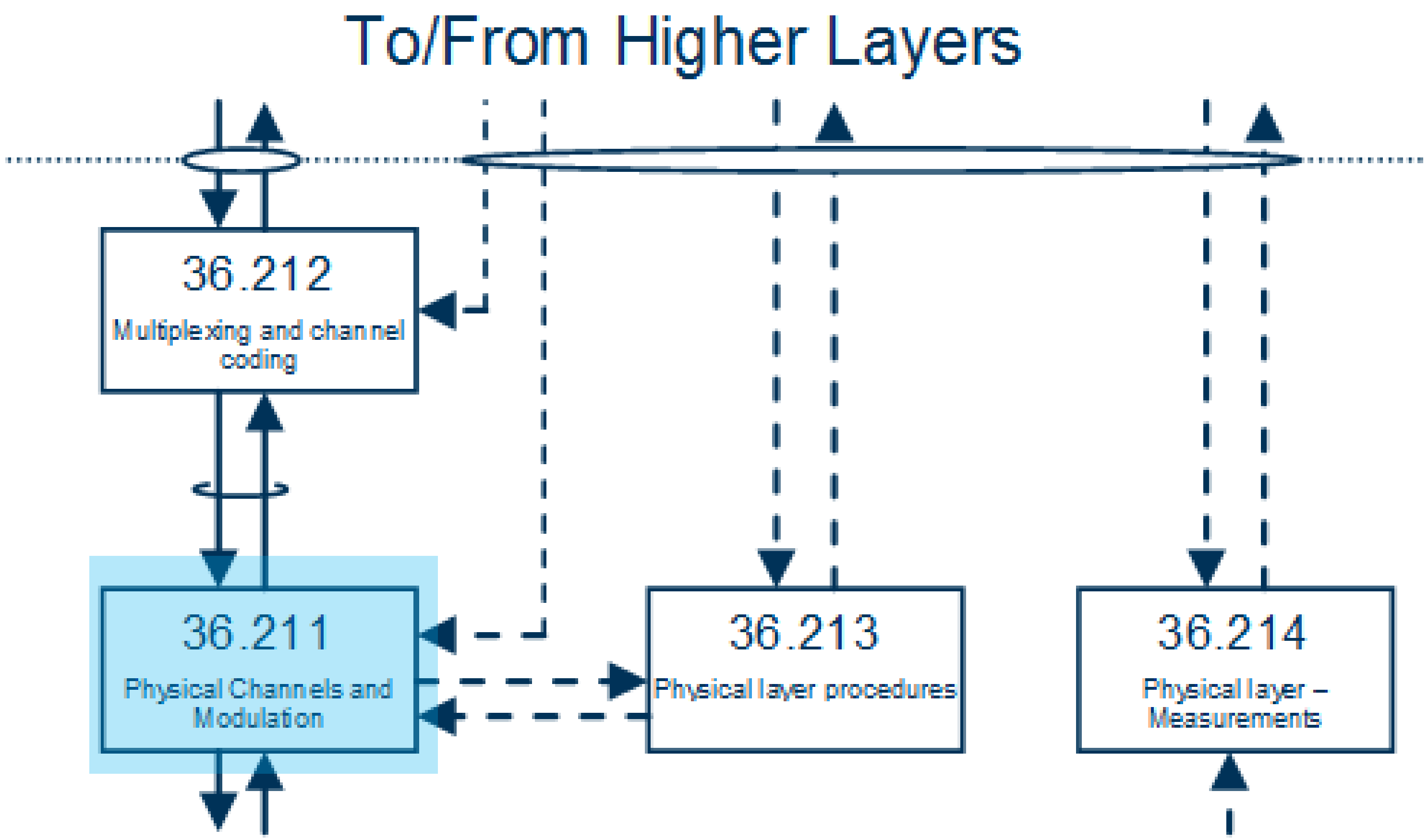
- Bits on the encoder input: $c_0, c_1, \dots, c_{K-1}$
- Bits at the encoder output: $d_0^i, d_1^i, \dots, d_{D-1}^i$, where D is the number of encoded bits per output stream and i is the encoder output stream index.
- Two coding schemes are applied on LTE
  - Tail biting convolutional encoding
  - Turbo Coding

On Link Simulations, we are interested on the channel that carriers data

TrCH	Coding scheme	Coding rate
UL-SCH	Turbo coding	1/3
DL-SCH		
PCH		
MCH		
BCH	Tail biting convolutional coding	1/3

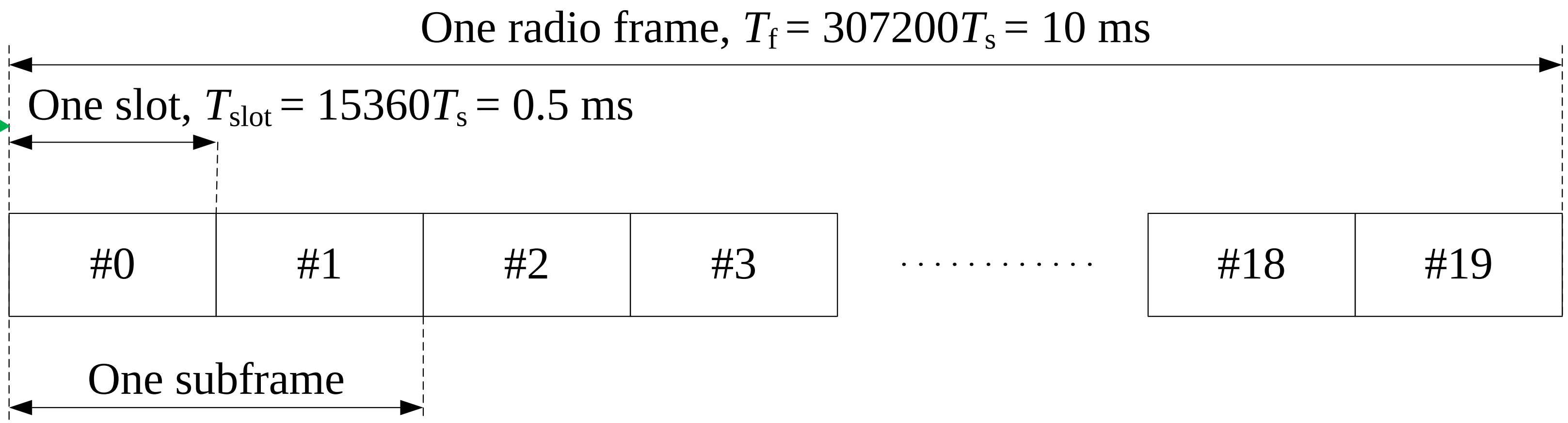
TS 36.211 – Physical Channels and modulation

Physical Channels and Modulation



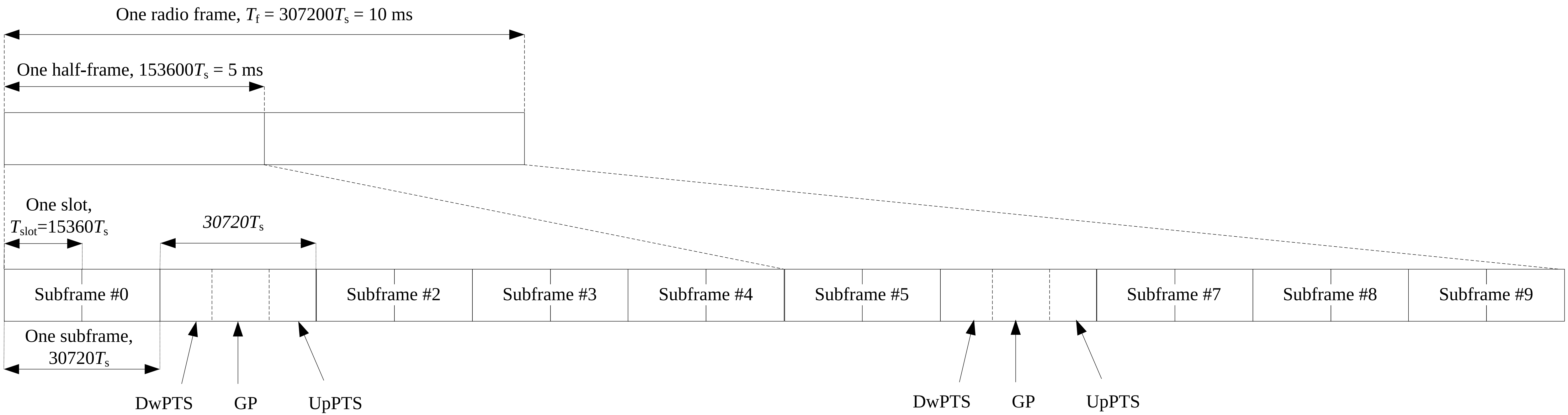
Frame structure – Type 1 (FDD)

This was agreed to be on the first version of implemented PHY



- Simpler
- More suitable for Link level simulations

Frame structure – Type 2 (TDD)



- There are special subframes used for switching between downlink and uplink transmissions

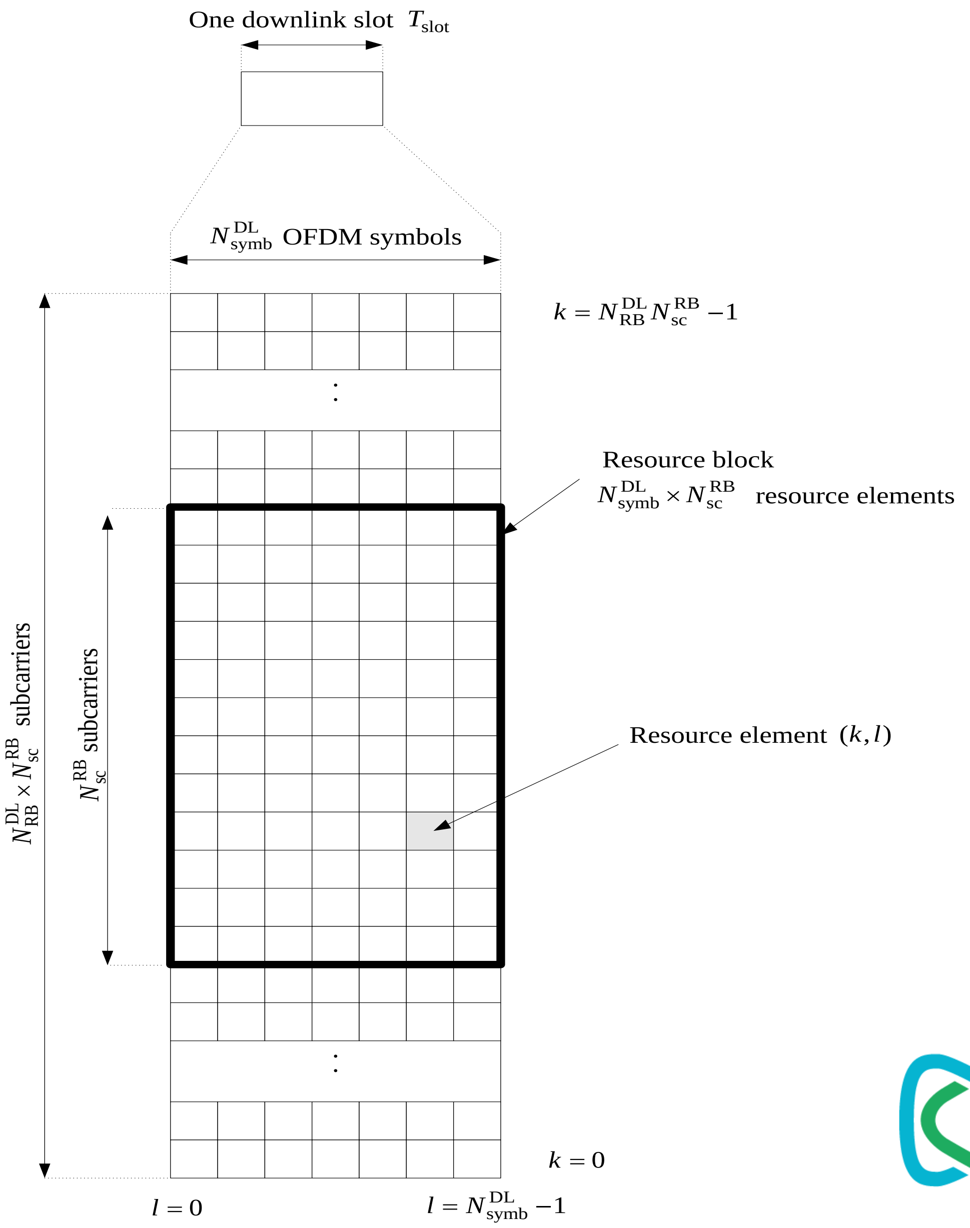
Frame structure – Type 2 (TDD)

- Frame configuration doesn't allow DL only or UL only simulations.

Uplink-downlink configuration	Downlink-to-Uplink Switch-point periodicity	Subframe number									
		0	1	2	3	4	5	6	7	8	**9**
0	5 ms	D	S	U	U	U	D	S	U	U	**U**
1	5 ms	D	S	U	U	D	D	S	U	U	**D**
2	5 ms	D	S	U	D	D	D	S	U	D	**D**
3	10 ms	D	S	U	U	U	D	D	D	D	**D**
4	10 ms	D	S	U	U	D	D	D	D	D	**D**
5	10 ms	D	S	U	D	D	D	D	D	D	**D**
6	**5 ms**	**D**	**S**	**U**	**U**	**U**	**D**	**S**	**U**	**U**	**D**

Downlink Description – Resource Elements

- Each element in the resource grid, identified by the index (k,l)
- $k = 0, \ldots, N_{RB}^{DL}\, N_{sc}^{RB} - 1$
- $l = 0, \ldots, N_{symb}^{DL} - 1$



Downlink Description – Resource Blocks

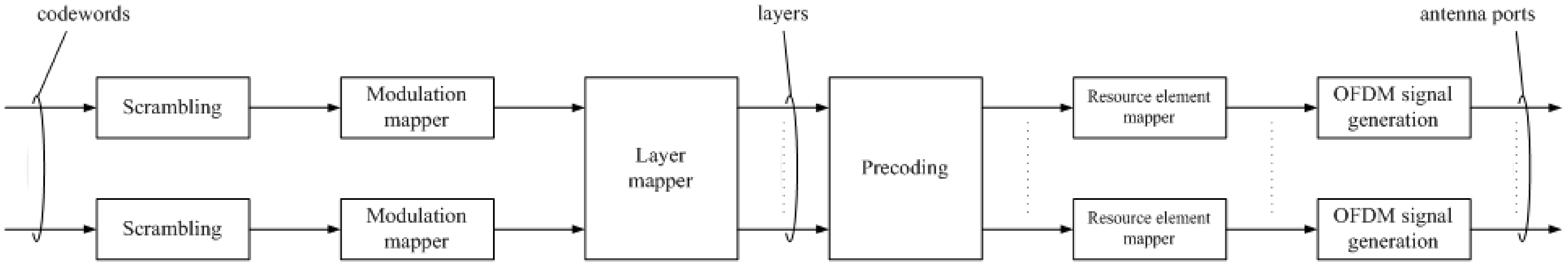
- Physical Resource block pair:
  - 2 physical RBs in one subframe having the same resource-block number
- $n_{PRB} = \left\lfloor \frac{k}{N_{sc}^{RB}} \right\rfloor$

This was agreed to be on the first version of implemented PHY

Configuration		N_{sc}^{RB}	N_{symb}^{DL}
Normal cyclic prefix	$\Delta f = 15\,\mathrm{kHz}$	12	7
Extended cyclic prefix	$\Delta f = 15\,\mathrm{kHz}$		6
	$\Delta f = 7.5\,\mathrm{kHz}$	24	3

INDT

Downlink Description – General structure



Downlink Description – Scrambling

- For each codeword q, the block of bits $b^{q}(0), \dots, b^{q}\left(M_{bit}^{q}-1\right)$ shall be scrambled prior to modulation, according to (Section 6.3.1):

$$\tilde{b}^{(q)}(i) = \left(b^{(q)}(i) + c^{(q)}(i)\right) \bmod 2$$

$$c_{\text{init}} = \begin{cases} n_{\text{RNTI}} \cdot 2^{14} + q \cdot 2^{13} + \lfloor n_s/2 \rfloor \cdot 2^{9} + N_{\text{ID}}^{\text{cell}} & \text{for PDSCH} \\ \lfloor n_s/2 \rfloor \cdot 2^{9} + N_{\text{ID}}^{\text{MBSFN}} & \text{for PMCH} \end{cases}$$

$$c(n) = \left(x_1(n+N_C) + x_2(n+N_C)\right) \bmod 2$$

$$x_1(n+31) = \left(x_1(n+3) + x_1(n)\right) \bmod 2$$

$$x_2(n+31) = \left(x_2(n+3) + x_2(n+2) + x_2(n+1) + x_2(n)\right) \bmod 2$$

$$N_C = 1600$$

- Where n_{RNTI} corresponds to the RNTI associated with the PDSCH described in clause 7.1 in TS 36.213

Downlink Description – Modulation

- For each codeword q, the block of scrambled bits $\tilde{b}^q(0), \dots, \tilde{b}^q(M_{bit}^q - 1)$ shall be modulated (TS 36.2011 – clause 7.1)

BPSK

$b(i)$	*I*	*Q*
0	$1/\sqrt{2}$	$1/\sqrt{2}$
1	$-1/\sqrt{2}$	$-1/\sqrt{2}$

16 QAM

$b(i), b(i+1), b(i+2), b(i+3)$	*I*	*Q*
0000	$1/\sqrt{10}$	$1/\sqrt{10}$
0001	$1/\sqrt{10}$	$3/\sqrt{10}$
0010	$3/\sqrt{10}$	$1/\sqrt{10}$
0011	$3/\sqrt{10}$	$3/\sqrt{10}$
0100	$1/\sqrt{10}$	$-1/\sqrt{10}$
0101	$1/\sqrt{10}$	$-3/\sqrt{10}$
0110	$3/\sqrt{10}$	$-1/\sqrt{10}$
0111	$3/\sqrt{10}$	$-3/\sqrt{10}$
1000	$-1/\sqrt{10}$	$1/\sqrt{10}$
1001	$-1/\sqrt{10}$	$3/\sqrt{10}$
1010	$-3/\sqrt{10}$	$1/\sqrt{10}$
1011	$-3/\sqrt{10}$	$3/\sqrt{10}$
1100	$-1/\sqrt{10}$	$-1/\sqrt{10}$
1101	$-1/\sqrt{10}$	$-3/\sqrt{10}$
1110	$-3/\sqrt{10}$	$-1/\sqrt{10}$
1111	$-3/\sqrt{10}$	$-3/\sqrt{10}$

QPSK

$b(i), b(i+1)$	*I*	*Q*
00	$1/\sqrt{2}$	$1/\sqrt{2}$
01	$1/\sqrt{2}$	$-1/\sqrt{2}$
10	$-1/\sqrt{2}$	$1/\sqrt{2}$
11	$-1/\sqrt{2}$	$-1/\sqrt{2}$

- 64 QAM is described onTable 7.1.4-1
- 256 QAM is described on Table 7.1.4-2

INDT

Downlink Description – Layer Mapper

- Complex-valued modulation symbols for each of the codewords should be mapped on 1 or several layers.
  - υ is the number of layers, M_{symbol}^{layer} is the number of modulation symbols per layer
  - $x(i) = [x^0(i) \dots x^{\upsilon-1}(i)], i = 0,1, \dots, M_{symbol}^{layer} - 1$

- **Single Antenna port**

$$\boldsymbol{x^0(i) = d^0(i)}$$

Downlink Description – Layer Mapper

- υ is the number of layers, M_{symbol}^{layer} is the number of modulation symbols per layer
- P is the number of antenna ports
- **Multiple Antenna Ports**
  - Spatial Multiplexing
    - ✓ $\upsilon \leq \mathrm{P}$
    - ✓ Codeword to layer mapping defined on Table 6.3.3.2-1
  - Transmit Diversity
    - ✓ $\upsilon = \mathrm{P}$
    - ✓ Codeword to layer mapping defined on Table 6.3.3.3-1

INDT

Downlink Description – Precoding

Falta fazer essa parte!!!!

INDT

Natural Partner for Innovation

THANK YOU

www.indt.org

communications@indt.org.br

INDT

INDT


4
:-)