TD4: LTE Peak Data Rate and NR Latency

Gabriel PEREIRA DE CARVALHO

Last modification: March 5, 2025

Question 1

The maximum possible signal bandwidth in LTE is 20MHz corresponding to 100 resource blocks.

Question 2

In the normal configuration, LTE has 7 OFDM symbols per slot.

Each radio frame has 20 slots $\implies$ 140 OFDM symbols per radio frame.

Now we do dimensional analysis to get the corresponding number of REs,

$$1 \text{ radio frame} \cdot \frac{20 \text{ slots}}{1 \text{ radio frame}} \cdot \frac{100 \text{ RBs}}{1 \text{ slot}} \cdot \frac{84 \text{ REs}}{1 \text{ RB}} = 168000 \text{ REs} \tag{1}$$

Question 3

To maximize the data rate, the control region occupies one OFDM symbol per sub-frame. So the number or REs is

$$1 \text{ OFDM symbol} \cdot 12 \text{ sub-carriers} \cdot 100 \text{ RBs} = 1200 \text{ REs} \tag{2}$$

Question 4

The PSS is transmitted in 2 slots per radio frame and mapped to 62 active subcarriers $\implies$ 62 REs per slot. So per frame we have 124 REs.

Similarly, the SSS is transmitted in 2 slots per radio frame and mapped to 62 active subcarriers $\implies$ 62 REs per slot. So per frame we have 124 REs.

The PBCH is transmitted in 4 slots per radio frame and mapped to 72 active subcarriers $\implies$ 72 REs per slot. So per frame we have 288 REs.

In total we have $124 \text{ REs} + 124 \text{ REs} + 288 \text{ REs} = 536 \text{ REs}$.

Question 5

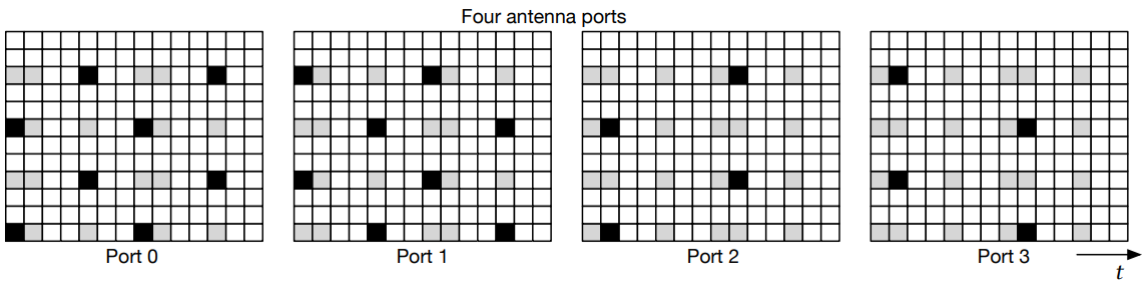

Figure 1: REs used for Reference signals for 4 antenna transmission

4 antennas $\implies$ 12REs per RB which is $\frac{12}{84} = 14\%$ of all REs.

Question 6

The densest modulation in LTE is 64-QAM. Each symbol in 64-QAM carries 6 bits.

Maximum number of MIMO parallel flows is 4 (using 4x4 MIMO, 4 input flows/output flows).

Duration of a radio frame is 10ms.

The number of REs transmitting useful data is $168000 \text{ REs} - 1200 \text{ REs} - 536 \text{ REs} = 166264 \text{ REs}$.

Raw peak data rate is

$$\frac{0.86 \cdot 166264\text{REs} \cdot 6\text{bits} \cdot 4\text{parallel flows}}{10\text{ms}} = 343.2\text{Mbps} \tag{3}$$

Question 7

We have $\frac{3}{4} \cdot 343.2\text{Mbps} = 257.4\text{Mbps}$

Question 8

The measured data rates are probably a bit smaller because we assume ideal channel conditions with no interference, no errors, no congestion and an idealized overhead.

Question 9

OFDM symbol duration

Without cyclic prefix we have $T_{\text{symbol}} = \frac{1}{\Delta f} = 33.3\mu s$

With cyclic prefix we have

$$T'_{\text{symbol}} = \frac{1}{\Delta f} + t_{\text{prefix}} = 33.3\mu s + 2.3\mu s = 35.6\mu s \tag{4}$$

Duration of the periodic scheme

We have 3 different periodic schemes: DDDSU, DDDDDDDSUU and DSDU.

The DDDSU scheme has 5 OFDM symbols per period $\implies T_{\text{DDDSU}} = 5 \cdot 35.6\mu s = 178\mu s$.

The DDDDDDDSUU scheme has 10 OFDM symbols per period $\implies T_{\text{DDDSU}} = 10 \cdot 35.6\mu s = 356\mu s$.

And the DSDU scheme has 4 OFDM symbols per period $\implies T_{\text{DDDSU}} = 4 \cdot 35.6\mu s = 142.4\mu s$.

Minimum and maximum DL latency

For maximal latency we consider the full duration of each scheme and for the minimal latency we consider the duration up to the first possible uplink symbol (can be U or S).

Frame Structure	**Min DL Latency**	**Max DL Latency**
DDDSU	4 symbols = 142.4 μs	5 symbols = 178 μs
DDDDDDDSUU	8 symbols = 284.8 μs	10 symbols = 356 μs
DSDU	2 symbols = 71.2 μs	4 symbols = 142.4 μs