

# **EITP30 Modern Wireless Systems - 5G and Beyond**

## **Exercise 20210924**

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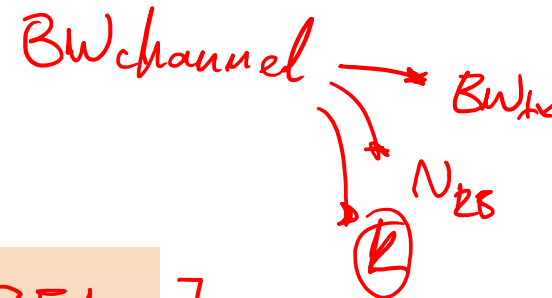
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# Exercise: Multi-antenna throughput

- Alice wants to watch a Netflix movie in her phone while she is on a train trip.
- The phone supports LTE, and has 2 antennas.
- Which video quality can she obtain?

Network information:

- In average, 16QAM is used.  $M = 16$
- Channel bandwidth allocated for Alice 1.4MHz.  $BW_{channel}$
- Coding rate 1/3  $r_c$
- Normal cyclic prefix  $N_{symb} = 14$



Netflix data usage:

- Low quality: 0.3GB/hour
- Medium quality: 0.7GB/hour
- High (HD): 3GB/hour
- High (UHD): 7GB/hour

Handwritten calculation for  $T_{tot}$ :

$$T_{tot} = 1 \text{ms} = \frac{8 \text{b}}{1 \text{B}} \cdot \frac{6 \text{B}}{h} \cdot \frac{1 \text{h}}{60 \text{min}} \cdot \frac{1 \text{min}}{60 \text{s}}$$

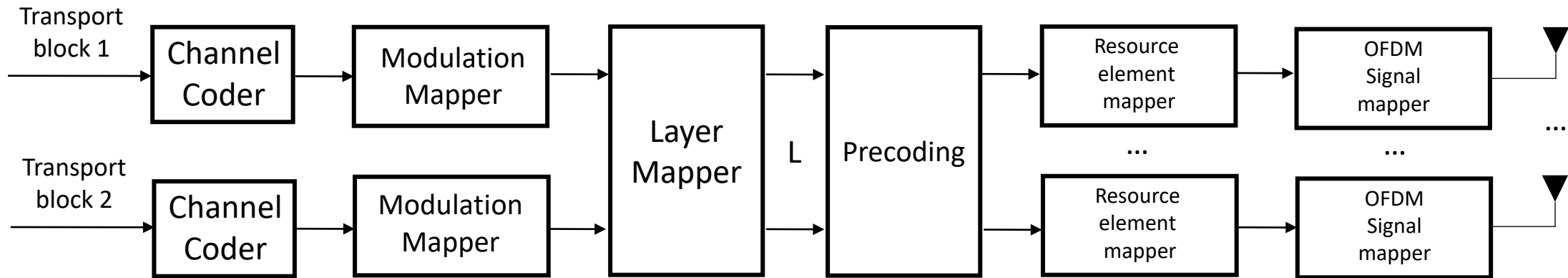
Handwritten calculation for  $R_{low}$ :

$$R_{low, \text{bps}} = \frac{R_{low, \text{GBph}} \cdot 8}{3600} = 8$$



# Exercise: Multi-antenna throughput

DOWNLINK



Transmission bandwidth configuration  $N_{RB}$

Channel bandwidth $BW_{Channel}$ [MHz]	1.4	3	5	10	15	20
Transmission bandwidth configuration $N_{RB}$	6	15	25	50	75	100

$$1 RB = 12 SCs \rightarrow$$

$$L = 6 \cdot 12 = 72$$

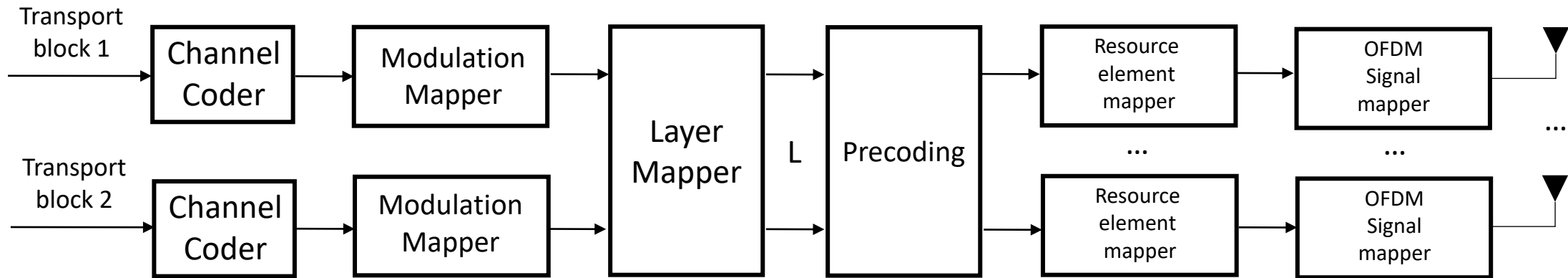
$$T_{symbol} = \frac{T_{sf}}{N_{symbol}^{sf}}$$

$$R_{uncoded}^{layer} = \frac{r_c \cdot K \cdot \log_2 M \cdot N_{symbol}^{sf}}{T_{sf}} = \frac{1}{3} \cdot 72 \cdot 4 \cdot 14}{10^{-3}} \text{ bps} = 1.344 \text{ Mbps}$$



# Exercise: Multi-antenna throughput

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$$R_{\text{uncoded}}^{\text{layer}} = 1.344 \text{ Mbps}$$

~~$$L = \left\lceil \frac{15.556}{1.344} \right\rceil = 12$$~~

Device has only 2 antennas  $\rightarrow$  Up to 2 layers  $\rightarrow L = \{1, 2\}$

UHD  $\rightarrow$  15.556 Mbps

$$R_{\text{uncoded}}(L = 2) = 2 \cdot R_{\text{uncoded}}^{\text{layer}} = 2.688 \text{ Mbps} \rightarrow \text{Medium Quality}$$

HD  $\rightarrow$  6.667 Mbps

Med. Q.  $\rightarrow$  1.556 Mbps

$$R_{\text{uncoded}}(L = 1) = R_{\text{uncoded}}^{\text{layer}} = 1.344 \text{ Mbps} \rightarrow \text{Low Quality}$$

Low. Q.  $\rightarrow$  0.667 Mbps

