

## Answers to the exam in Modern Wireless Systems - LTE and Beyond October 2014.

1.

- a) True since  $\eta = 15$  kps/Hz (at most).  
So,  $R_b = 15 \cdot 40 \cdot 10^6 = 600$  Mbps.
- b) True since then the aggregated channel can be estimated.
- c) False since there is no BCH in subframe 5 after the PSS.
- d) False since, e.g., it is not assumed when Transmit Diversity,  $t_x$  (Tx mode 2) is used.
- e) False since only 1/2 control signals are sent in the control region. The DL-SCH also contains some control signals, see Figure 8.7.
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2.

- a) Since PCFICH = 2, 12 OFDM intervals can be used to send user data carrying coded bits within a RB-pair. However, in these 12 intervals, 12 RE are used for CRS.  
64-QAM  $\Rightarrow 6(12 \cdot 12 - 12) = 792$  coded bits/RB-pair for each antenna.  
83 RB-pairs  $\Rightarrow 65.736$  Mcbps/antenna  
So, 131.47 Mcbps in total.

- b) The estimates  $\hat{h}_{p,3}, j=1, 2, \dots, N_r$ , are obtained and  $N_r = 4$ . (The third antenna is port 2.)  
 $h_{p,3}$  is here representing the channel in the specific RE and to a specific UE.  
See also Figure 10.10.

- c) From Table F.1 it is seen that the improvement factor is 10 in the DL and 20 in the UL. The reason is that the number of transmitter antennas is doubled in the DL, and increased a factor four in the UL. Also, the bandwidth is increased a factor 5.
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3.

a) PUSCH: DFT-precoding is used.

11-12 OFDM intervals can be used in a subframe,  $N$  frequency-contiguous RB-pairs are scheduled (i.e. one cluster) in Rel-8/9. Two clusters are allowed in Rel-10.

PDSCH: several RE blocked by ref. signals. The control region (1-3 OFDM int.) must be avoided.

Type 0,1: non-cont. allocation of RBs.

Type 2: cont. allocation of RBs.

b) Please see the course book.

c) DL: RI, PMI and CQI can be obtained from <sup>CRS</sup>.  
UL: SRS is used

c) L1/L2 are sent with transmit diversity. ALSO, transmission mode 2 is a "fall-back" mode for DL-SCH transmissions

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4. a) The DFT is used at each DL and UL receive antenna to extract information-carrying signal components (at all sub-carriers).

DFT precoding is used at each transmitting antenna in UL to reduce the PAPR.

b) False since other non-active users place L1/L2 control information at the two edges of the bandwidth.

c) Please see the course book

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a)

False since the spectral multiplexing gain is at most equal to  $\text{rank}(H) = 2$ . Hence, if  $\text{rank}(H) = 1$  then no spectral multiplexing gain can be obtained (=1, i.e. SISO).

b) The relationship between  $C_{\text{BW}}$  and  $S/N_0$ . The requirement on  $S/N_0$  if  $R$  is increased for fix ratio  $R/\text{BW}$ .

Adaptive user bandwidth is used in LTE, and different users may have very different value of  $S/N_0$ . The value of  $C$  gives us an upper bound indication of which bit rates can be expected to be used in reality.

g)

Rel-8: ICIC

Coordinated scheduling is useful in <sup>cases</sup> many.

Macro-Pico layer

Relays: Backhaul  $\leftrightarrow$  Access

Near-Far problem

Please <sup>see</sup> the course book for more details concerning the examples above.

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