141013/GL

Answers to exam in the course Modern Wireless Systems – LTE and Beyond (ETTN15), October 21, 2013, 08-13.

1.

a) True for downlink since 3Gbps/5=600 Mbps.

b) False since only single antenna transmission is used.

c) False since CRS symbols are only used in the downlink.

d) False, the first step in the random access procedure is made without an uplink timing advance command.

e) False, since in downlink at most four transmitting antennas can then be used.

2.

a)

i) 8 resource elements are blocked by CRS symbols in a resource-block pair. So, 95.24% are useful.

ii) 16 resource elements are blocked by CRS symbols in a resource-block pair. So, 90.48% are useful.

iii) 24 resource elements are blocked by CRS symbols in a resource-block pair. So, 85.71% are useful.

b) Please see sub-section 10.4 in the course book.

c) OFDM-interval number 8 and the m:th sub-carrier are considered below. Using conventional MIMO description we have that:

$$Z_j(m) = \sum_{i=1}^{N_t} h_{j,i}(m)\, s_i(m) + n_j(m)$$

3.

a) No, it is a waste of bandwidth resources since it is not possible to communicate high bit rates to this user (Shannon).

b) T1 DL: Interfering signals originating from the base station in cell A may appear if the same resources as in T1 DL are used.

T1 UL: Interfering signals originating from all terminals located close to the cell border of the current cell, but outside the current cell, may appear if the same resources as in T1 UL are used.

c) Loss of orthogonality typically is the result. Hence, after DFT the two signals will cause interference to each other. The strong interference obtained from T2 will “destroy” the weak information carrying signal from T1.

4.

a) 6 RB-pairs are assigned, but only 11 OFDM intervals can be used in this sub-frame, since 3 OFDM intervals are used by reference signals. Hence, 792 resource elements can be used for PUSCH transmission.

b) If only L1/L2 control signals are sent, then they are placed at the two edges of the overall spectrum. If UL-SCH and L1/L2 control signals are sent simultaneously, then L1/L2 signals are time-multiplexed with the coded UL-SCH before DFT precoding.

c) Let G denote the DFT precoding matrix. Then the column vector **z** at the base station that is a result of the column vector **a** in the terminal can be expressed as:

$$Z(m) = h_{4,1}(m)\, y(m) + n_4(m), \quad \underline{y} = G\underline{a}$$

$$\underline{Z} = \begin{pmatrix} h_{4,1}(1) & & 0 \\ & h_{4,1}(2) & \\ 0 & & \ddots \end{pmatrix} G\underline{a} + \underline{n}_4$$

To be able to estimate the column vector **a** one has to take into consideration that the channel parameters above typically have different values.

5.

a) From Rel.-10, 4 transmit antennas, spatial multiplexing gain 4, 100 MHz bandwidth, 64 QAM.

b) Please see sub-sections 10.3.3 – 10.3.4 in the course book.

c)

At terminal 1: $r = (h_{11} \ h_{12}) W \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} + n$

At terminal 2: $r = (h_{21} \ h_{22}) W \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} + n$

Hence, if $W = k \cdot H^{-1}$, where k is a transmitter power normalization parameter, then the desired situation occurs.