

**TLT-6106 Basic Course on Wireless Communications, Exam 16 January 2012, Please give the answers in English. Students' own calculators or faculty's calculators are allowed.** The attached 2-page formulas are allowed. Exam's compiler: Simona Lohan, TG116.

- (6p) Describe the basic principles of FDMA and CDMA multiple access schemes. Use illustrative block diagrams to explain these concepts. Compare FDMA with CDMA: basic principle, advantages, and disadvantages. Give examples of systems which employ FDMA and CDMA technologies.
- (6p) A commercial mobile receiver for data transmission is specified with a sensitivity of -100 dBm (dBm=power in dB per mW). Assuming a 1 mW transmit power, a transmission frequency of 2.1 GHz, transmitter (or base station) antenna height of 10 m, and receiver antenna height of 0.01 m, what would be the radius of service area under the following path loss models?

a)  $L_{dB} \approx 120 + 40 \log_{10} d_{km} - 20 \log_{10} h_{T,m} h_{R,m}$  *two ray-model*

b)  $L_{dB} \approx 32.44 + 20 \log_{10} d_{km} + 20 \log_{10} f_{MHz}$  *free space loss model*

c)  $L_{dB} = 46.3 + 33.9 \log_{10} (f_{MHz}) - 13.82 \log_{10} (h_{T,m}) + (47 - 6.55 \log_{10} (h_{T,m})) \log_{10} (d_{km})$  *Empirical path loss model*

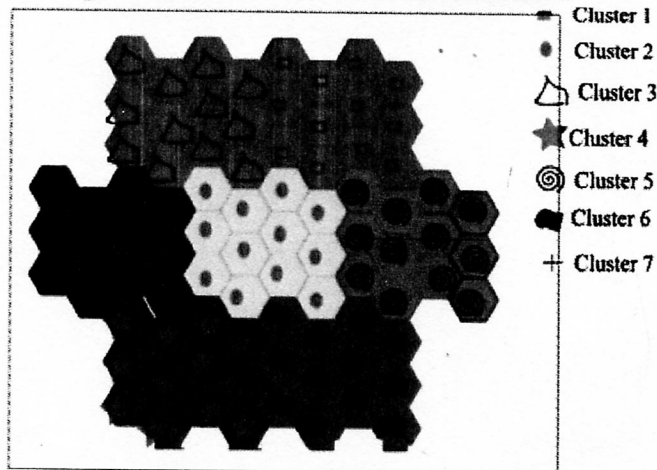
$h_{T,m}$  is the transmit antenna height in meters and  $h_{R,m}$  is the receive antenna height in meters.

To which path loss model each of the formulas above corresponds?

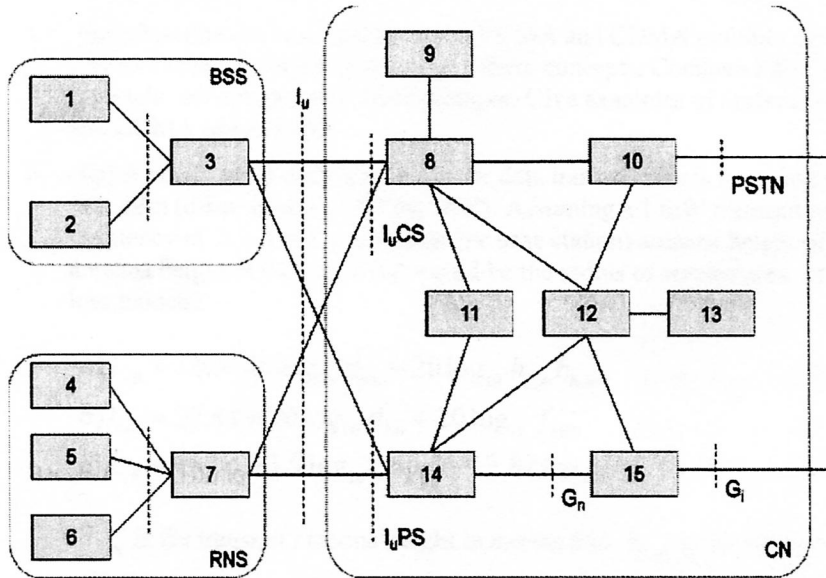
At equal cell radius, for which of the 3 models above do you get the minimum path loss and why?

How is the path loss varying with the distance (in linear scale) for these models?

- (3p) Describe briefly the following concepts: i) Soft handover, ii) Isotropic antenna, iii) Multipath propagation, iv) Fading, v) Inter-symbol interference (ISI), vi) Antenna gain.
  - (3p) What is the cluster size (N) in the figure below? If the cell range is  $R=300$  m, what is the value of the re-use distance? What is the value of the Signal to Interference ratio (SIR) in decibels for this cluster size, in an environment with the path loss factor  $n=4$ ? What about SIR in an environment with path loss factor  $n=2$ . Discuss the differences.



4. (6p) The following block diagram shows the simplified GSM+UMTS network architecture. Explain the name and functionality of each of the blocks from 1 till 15. Hint: some blocks have the same functionality/name. Based on this block diagram, compare GSM system architecture with UMTS system architecture, by emphasizing the similarities and differences. Gives some examples of data rates typical for GSM and for UMTS based connections.



5. a) (3p) Two DS-SS spreading codes in vector form are  $s_1 = [-1 \ 1 \ 1 \ -1 \ -1]$  and  $s_2 = [1 \ -1 \ 1 \ -1 \ 1]$ . Calculate the cross correlation values between the spreading code  $s_1$  and signal  $s_1$  which is defined as a bit sequence  $b_1 = [1 \ 1]$  spread by  $s_1$ . What is the spreading factor? What is the processing gain in dB?
- b) (3p) Make a judgment on the evolution and challenges on the future wireless networks (write down your ideas what will be next and what are the challenges we have to cope with). Think about the physical layer and Medium Access Control (MAC) layer requirements and how to achieve them.