Please answer all the five problems. Use of pencil is allowed.

Vastaa kaikkiin viiteen tehtävään. Lyijykynän käyttö on sallittu.

University of Oulu

521323S WIRELESS COMMUNICATIONS I
Final Exam 11.12.2017

1. How are the signals distinguished and selected for digital transmission (three cases)? What is meant by M level modulation and how it relates with the sequence coming to the modulator, when sequence has input rate R which is inverse proportional to bit interval? What is transmission rate in the channel in this case?

2. a) When do you need carrier phase synchronization and when symbol synchronization in digital communications?
    b) What means acquisition and tracking mode in synchronization?
    c) Which criteria are used with adaptive equalizers to optimize coefficients?

3. Explain the idea of diversity in communications? What kind of diversity methods exist: explain the principle for at least three methods. What kind of combining is used in the receiver with diversity, so that the gain is obtained: explain the principle for at least three methods.

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4. You are travelling **from *Rovaniemi* to *Helsinki*** without any hurry in four days. In the map below (Figure 1), you can find the possible routes. You will stay overnight as follows:
   1. night: *Kuusamo* or *Oulu.*
   2. night: *Vaasa* or *Joensuu*
   3. night: *Tampere* or *Turku.*

Select **the shortest** route using **Viterbi algorithm** (4 p.). Draw enough intermediate steps so that the Viterbi algorithm idea can be easily seen (**this is important!**).

What is the length of the route (1 p.) in kilometers, and which places you will visit (1 p.)?
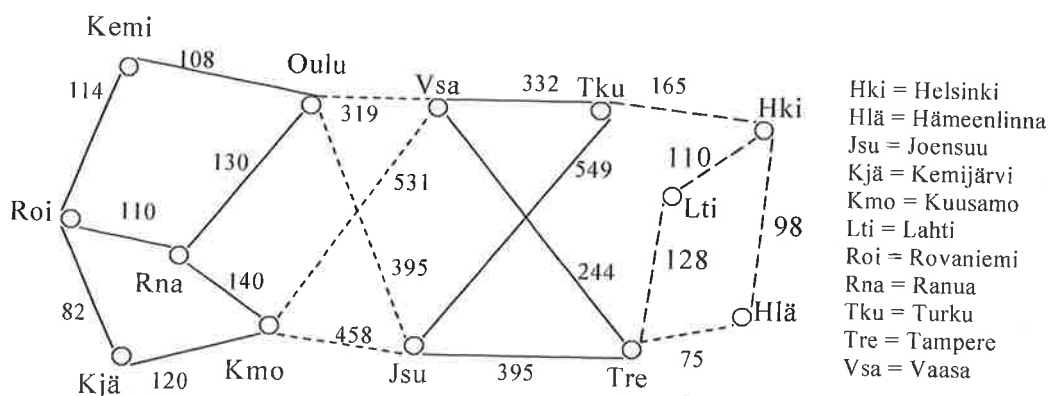

Figure 1. Map for the routes.

5. For a multipath fading channel let a scattering function $S_c(\tau,\rho)$ is nonzero over $0 \le \tau \le 10$ µs and $-3000 \le \rho \le 3000$ Hz. Assume that the power of the scattering function is approximately uniform over the range where it is nonzero.

   a) What are the multipath spread and the Doppler spread of the channel (numerical values)? **Explain** what the meaning of these spreads is.

   b) Suppose you input to this channel two identical sinusoids. What is the minimum value of Δf for which the channel response to the first sinusoid is approximately independent of the channel response to the second sinusoid? **Explain** you answer.

   c) For two sinusoidal inputs to the channel $u_1(t) = \sin 2\pi f t$ and $u_2(t) = \sin 2\pi f(t + \Delta t)$, what is the minimum value of Δt for which the channel response to $u_1(t)$ is approximately independent of the channel response to $u_2(t)$? **Explain** you answer.

   d) Will this channel exhibit flat fading or frequency-selective fading for channel with a 2 kHz bandwidth? How about for a channel with a 400 kHz bandwidth? **Explain** you answer.

   e) Assume that $BT_s \approx 1$. Is there fast or slow fading, if we use these bandwidths (2 kHz and 400 kHz)? **Explain** you answer.