institute of telecommunications

TECHNISCHE UNIVERSITÄT WIEN Vienna University of Technology

Homework 7

VU Wireless Communications 1, 389.157, SS 2014,
Veronika Shivaldova, veronika.shivaldova@nt.tuwien.ac.at

Important for getting a grade:

- Answer all questions tagged with boxes such as XY short and precise, and state the question number next to the solution.
- Put the homework into the box located at the 1st floor of the *Institute of Telecommunication*, or send it to veronika.shivaldova@nt.tuwien.ac.at.
- Attend the exercise lecture and be prepared to be called to the blackboard for presenting your results.
- In case questions arise, do not hesitate to contact me!

1 Basics of GSM

- The forward link bandwidth of GSM cellular mobile phone standard is 25 MHz and is subdivided in channels of 200 kHz each. Further, the transmission is divided into temporal frames consisting of 8 time slots, each being assigned to a single user. In each slot user can transmit 6 trailing bits, 8.25 guard bits, 26 training bits and two data bursts each 58 bits long.

5 p 1 Calculate maximum number of users supported simultaneously by a cell, assuming a cluster size of 7.

5 p 2 If user is allowed to start transmission each 4.615 ms calculate the duration of a frame, of a slot and of a bit.

5 p 3 Calculate the number of overhead bits sent by a single active user in a second.

- As you know, TDMA requires precise timing of both the mobile station (MS) and base transceiver station (BTS) systems. When a MS wants to gain access to the network, it sends an access burst on the random access channel. Since the users are at various distances from the base station and radio waves travel at the finite speed of light, the further away the MS is from the BTS, the longer it will take the access burst to arrive at the

BTS. Eventually there comes a certain point where the access burst would arrive so late that it would occur outside its designated time slot and would interfere with the next time slot. Therefore, the time at which the MS is allowed to transmit a burst of traffic within a time slot must be adjusted accordingly to prevent collisions with adjacent users. Timing advance is the variable controlling this adjustment. The timing advance is a six bit parameter, with each step representing an advance of one bit period.

5 p [4] Calculate the maximum delay that can be compensated by means of timing advance.

5 p [5] Assuming that timing advance covers the complete round trip (MS - BTS, BTS - MS), calculate the maximum coverage area of a hexagonal cell.

2 Basics of UMTS

A provider has launched a new UMTS system, downlink packet transmission of which is based on frequency division duplex (FDD) with spreading factor of 64 and code-rate 1/2. After testing the system for its reliability, an average packet error rate of 20 % has been obtained.

5 p [6] Assuming that the lost/corrupted packets can be retransmitted by the network arbitrary often until they eventually reach the destination, calculate how many times packets are transmitted on average?

5 p [7] What is the most probable number of retransmissions?

5 p [8] Calculate the probability that the number of retransmissions $K < 5$?

5 p [9] Calculate the probability that the number of retransmissions $K > 3$?

5 p [10] Given that a packet already was transmitted once, how large is the probability that it will be retransmissions two more times?

5 p [11] Which data service format with respect to throughput (average number of successfully transmitted info bits per second) and delay would you suggest to use for mobile voice services:

- with no retransmissions and therefore data loss of 20 %, or
- with no information loss and unlimited number of retransmissions?

Hint: Following approximation might be usefull $\sum_{k=m}^{N} q^k = \frac{q^m - q^{N+1}}{1-q}$.

3 Rake Receiver

- Similarly to MATLAB exercise of last assignment generate a random signal $c_1(t)$ as follows:

$$c_k(t) = \sum_{n=1}^{10} a_k[n] \cdot p(t - nT_c),$$

where $a_k[n] \cdot p(t - nT_c)$ is a rectangular pulse with random amplitude $a_k \in \{\pm 1\}$ and bit duration T_c.

- Spread the generated signal using a spreading sequence $b_1 = [1, -1, 1, -1]$.

- Implement the transmission of the spreaded signal over a discrete-time FIR channel (do not consider noise here!) with channel impulse response

$$h[n] = 0.8 \cdot \delta[n] + 0.2 \cdot \delta[n-2] + 0.3 \cdot \delta[n-3].$$

10 p [12] Using the MATLAB function `stem` show the initial signal c_1, the spreaded signal $c_1 s_1$ and the spreaded signal after transmission over the three-tap channel, denoted by $c_1 s_1 ch$.

- In order to reconstruct the transmitted signal use a rake receiver, which is implemented as shown in Fig. 1. At the output of the rake receiver implement a hard decision block.

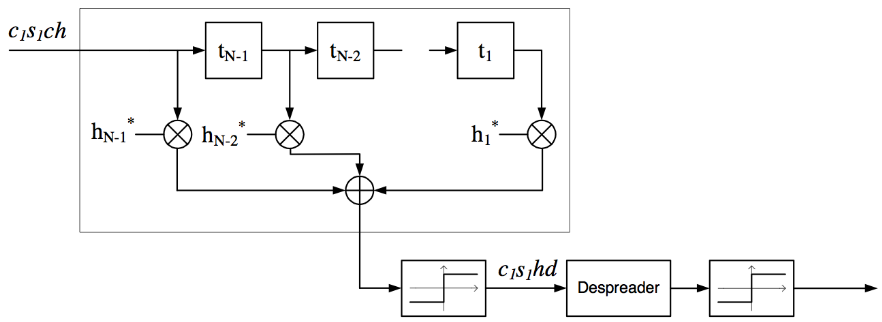

Figure 1: Schematic representation of rake receiver.

10 p [13] Use the MATLAB function `stem` to show that the output of the hard decision block, denoted by $c_1 s_1 hd$, is equal to the spreaded sequence $c_1 s_1$.

10 p [14] Despread the signal $c_1 s_1 hd$ and show that it is equal to transmitted signal c_1.

- Now add white Gaussian noise to your signal and define SNR at the input of the receiver as the ratio between the power of signal $c_1 s_1 ch$ and the noise power. Consider SNR values in the range [-10 dB, 10 dB] with steps of 1 dB.

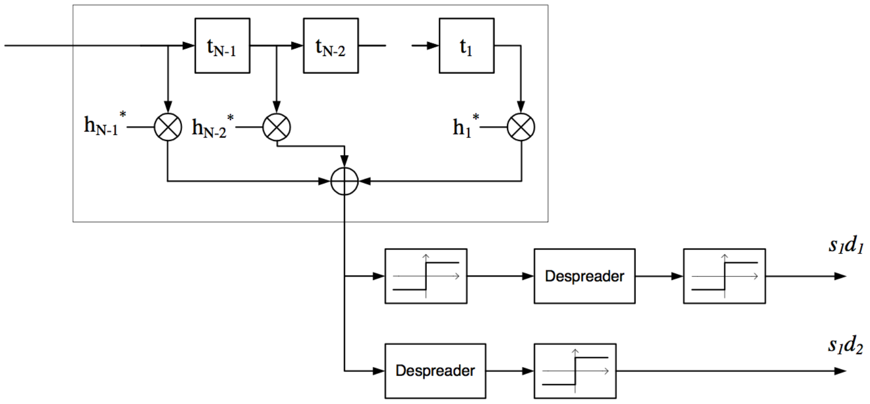

Figure 2: Schematic representation of rake receiver with two outputs.

15 p

15 Would the performance of the receiver change if you decide not to use hard decision block at the output of the rake receiver? Prove your answer by implementing both methods (with and without hard decision block at the output of the rake receiver) in your simulation, as shown in Fig. 2. Plot the symbol error rate as a function of SNR for both methods and compare them. Use a signal length of 1000 and at least 100 simulations for each SNR value.