ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE
School of Computer and Communication Sciences

Handout 22 Principles of Digital Communications
Project Apr. 17, 2019

Goal: The purpose of this PDC project is to complement the theory with a hands-on experience. What you do in this project is not very different from what a communication engineer might do to test the feasibility of a concept.

Assignment: Develop a system capable of reliably transmitting text files over a continuous-time channel with impairments. Specifically:

- Design a transmitter that reads a text file and returns real-valued samples of an information-bearing signal $s[n]$.
- You send $s[n]$ to a server that applies channel effects, returning $r[n]$.
- Having received $r[n]$, your designed receiver must reconstruct the contents of the text file.

Channel Effect The channel output signal $r[n]$ is linked to the input $s[n]$ through the relation

$$r[n] = (h \star s)[n] + N[n],$$

where h is a causal passband filter and $N[n] \sim \mathcal{N}(0, \sigma^2)$. Moreover we assume that h is stochastic in the following sense: each time you send a complete transmission to the channel server, $h_{\mathcal{F}}$ takes the form

$$h_{\mathcal{F}}(f) = \sum_{k=1}^{4} h_{\mathcal{F}}^{(k)}(f) - h_{\mathcal{F}}^{(i)}(f)$$

$$h_{\mathcal{F}}^{(k)}(f) = \begin{cases} \alpha, & |f - 2000k| \leq 1000, \\ 0, & \text{otherwise}, \end{cases}$$

where $i \in \{1, 2, 3, 4\}$ is chosen uniformly at random, and $\alpha \in (0, 1]$ is some constant. Figure 1 shows one possible filter realization.

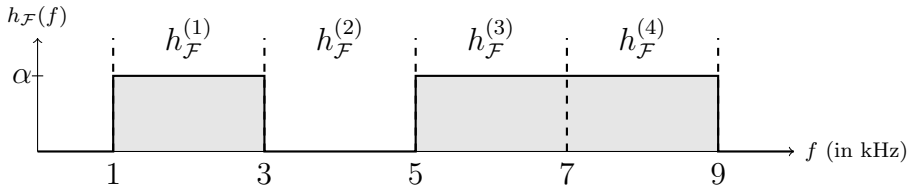

Figure 1: Spectrum of h when $i = 2$.

Rules and Recommendations:

- You work in teams of *two or three*.

  Please choose your teammates at latest by **Friday, May 10** and send an email to `sepand.kashani@epfl.ch` in order to register your team.

- We recommend you use Python or MATLAB as the programming language, but any other satisfactory solution is also accepted, as long as all the code pertaining to the transmitter and receiver is produced by your team.
- During the last session (May 31), each group presents their project in 5–10 minutes and gives a demonstration by transmitting a file that we provide.
  (i) You will run the transmitter and the receiver on your own laptop.
  (ii) You must send us your code before **Wednesday, May 31, 10am**.
  (iii) The text file which you will be asked to transmit will contain *roughly 160 characters/bytes*.
  (iv) Your presentation should contain a brief explanation of your signaling scheme, followed by the transmission and decoding of the chosen text (that will be given to you on the spot).
  (v) You will be given *two* chances for transmission. I.e., if the received text is different than the sent one at the first attempt, you can repeat the transmission once more.
- Reliability plays the most important role in the evaluation. Hopefully the communication will be error-free. The data rate and the implementation details play a secondary role.
  (a) If you manage to transmit the file without errors during the first transmission you will get the full mark (15/15 pts).
  (b) In case of error-free transmission in the second attempt you will get 12 pts out of 15.
  (c) Otherwise your mark will be $(1-\varepsilon)\times 12$ (out of 15 pts) where ε is the fraction of incorrect *words* in the reproduced text at the receiver.
  (d) On top of that, the group with the fastest transmission scheme (among the error-free ones) will get 5 additional (bonus) points.

Channel Access: To simplify communication with the channel server, we provide you a Python script `client.py` that you can download on the course webpage. Please read the associated docstrings for more information. Some extra information:

- Real-world transmitter/receiver front-ends can reliably quantize signals on a finite interval only. We replicate this behavior in the channel by clipping your inputs to $[-1, 1]$.
- Sampling rate: $f_s = 22050$ [samples/s].
- $\sigma^2 = 0.1$
- `--srv_hostname=iscsrv72.epfl.ch`
- `--srv_port=80`

Note: This project is meant to be instructive and enjoyable. It accounts only for 15% of the points that you can accumulate towards your final grade. Do not let it become a major time investment unless you can afford to do so. In particular, we strongly recommend that you do not let the project keep you from fulfilling the other assignments (for PDC and other classes). Remember that the final exam accounts for 40% of the points.