REDS Institute
Haute École d'Ingénierie et de Gestion du Canton de Vaud

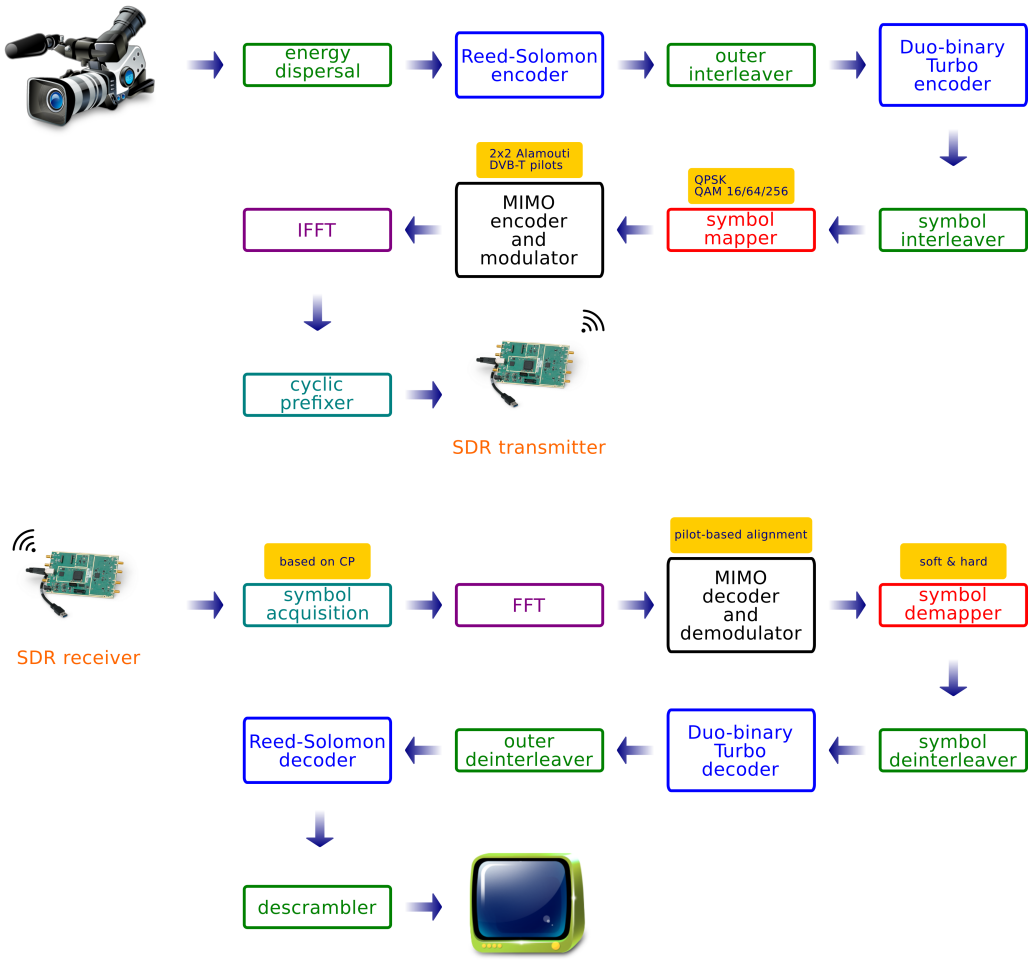
2019 Software Defined Radio RESEARCH TOPICS

Introduction

The REDS Institute (web site) is located in Yverdon-les-Bains (map), not far from Lausanne and the Swiss Riviera (Montreaux, Vevey). It is 270 km from Torino and on the shores of Neuchâtel lake. The Institute is led by 6 professors and very active in the embedded systems domain with projects and competences ranging from hardware board design to OS development, from FPGA implementations to algorithm design. Our web site will give you more information.

Topics

At the REDS institute we have developed several complete SDR platforms. One of them is a complete, SDR-based, SISO+MIMO TX/RX chain for MPEG streaming inspired by the DVB-T/DVB-T2 standards.



For this system we have a MATLAB simulation model (used to quickly validate ideas), a GNU Radio (C++) system that works successfully over the air, and we are close to have a complete VHDL implementation.

We are, however, interested in pursuing new research directions with the goal of improving the performance of our system. In particular, we would like to investigate the following topics:

- **Non-Uniform Constellations.** The ATSC 3.0 standard is the first major standard that foresees the adoption of Non-Uniform Constellations (NUCs) [1], claiming a significant gain. We would like to explore the impact of this technique in the context of our system, evaluating both the improvements on the BER and the increase in complexity of the demapper, both in simulation and on the real platform.
- **Turbo Equalization.** Turbo equalization [2, 3], especially in the context of MIMO systems such as ours, is a technique deemed to apport massive improvements. We would like to further investigate the applicability of this technique in a real system.
- **LDPC.** Though we have based our chains on a Turbo FEC, we would like to observe the performance of other FECs, in particular Low-Density Parity-Check (LDPC) codes [4].
- **MIMO algorithms.** For our system, after having analyzed the literature and having performed extensive simulations, we have chosen to adopt an Alamouti MIMO scheme. We are, however, very interested in the other major MIMO techniques (such as VBLAST [5]), and we would love to experiment on a real implementation of these algorithms to have a grasp on the relative improvements and the computational costs involved.
- **Channel Estimation algorithms.** Channel estimation techniques have been the subject of an extensive literature due to the importance they have once the protected playground of simulations is left [6]. However, most proposals have little or no experimental validation, making it difficult to select the most appropriate technique for a given situation. We are very interested in improving the approach used in the current system, thus we would like to develop a testbed including the major techniques available in literature, perform real-life measurements and comparisons, and if necessary perform algorithmic improvements.
- **Blind Channel Estimation algorithms.** Our current system, as suggested by the DVB-T standard, uses scattered pilots for channel estimation purposes. These pilots consume a non-negligible portion of the bandwidth (around 7%), thus removing them would lead to a significant increase in data rate. To this purpose, blind algorithms allow to achieve a non-data-aided channel estimation [6]. Again, these approaches are mostly validated in a simulated context and their behavior, when faced with the weirdness of a real-life wireless medium, is thus difficult to predict. We are motivated to perform an extensive measurement campaign aimed at evaluating their feasibility in the context of our system.
- **Digital Pre-Distortion.** Digital Pre-Distortion techniques [7] are an effective approach to ensure the respect of the transmission masks allocated by authorities, reducing adjacent channel leakage and thus allowing an improved exploitation of the available bandwidth. With the explosion of wireless communications, hardware implementations are becoming mainstream (see, for instance, the newest RFICs from Analog Devices). However, their increased power consumption makes them unfit for mobile platforms with a limited power budget (as it is the case for our system). We are therefore interested in further investigating software approaches that exploit the availability of an FPGA on our system to properly shape the transmitted signal.

Work Description

The thesis will focus on one of the aforementioned techniques, selected based on your knowledge, interests, and our needs. Independently form the specific topic chosen, the work will be organized as follows: for the six months of your thesis you will be part of a project team where you will have the opportunity to learn from experienced engineers and scientists; you will integrate and test your developments in real working systems. The institute is equipped with many prototyping RF systems and if your research will evolve from a theoretical model to C++ and then FPGA implementation, you'll be able to measure the performance of your ideas over the air.

Important

In order to work with us you have to be eligible for a Swiss student VISA. This is normally not an issue for European citizens, but could potentially take long time and have extra requirements based on your citizenship. Please contact me or Prof. Masera if you need to discuss this point in deeper details. Our University's foreign affair office will be happy to deal with all the bureaucracy.

On top of a stimulating working environment, the selected candidate will be supported with free accommodation and a scholarship of $400CHF$ per month. Please consider that living costs in Switzerland are higher than Torino.

For any question do not hesitate contacting me at: alberto.dassatti@heig-vd.ch

References

[1] N.S. Loghin et al., "Non-Uniform Constellations for ATSC 3.0," IEEE Transactions on Broadcasting, 2016.

[2] R. Koetter, A.C. Singer, M. Tuchler, "Turbo equalization," IEEE Signal Processing Magazine, 2004.

[3] M. Tuchler, R. Koetter, A. C. Singer, "Turbo equalization: principles and new results," IEEE Transactions on Communications, 2002.

[4] R.G. Gallager, Low-Density Parity-Check Codes. MIT Press, 1963.

[5] G. J. Foschini, "Layered space-time architecture for wireless communication in a fading environment when using multi-element antennas," Bell Labs Technical Journal, 1996.

[6] Y. Liu et al., "Channel Estimation for OFDM," IEEE Communication Surveys and Tutorials, 2014.

[7] J. Wood, "Digital pre-distortion of RF power amplifiers: progress to date and future challenges," in IEEE MTT-S International Microwave Symposium, 2015.