SDR-Based Channel Emulator using a Semi-Stochastic Radio Propagation Model

Johannes Schmitz, Xiang Xu, Florian Schröder, Milan Zivkovic, Rudolf Mathar
Institute for Theorectical Information Technology
RWTH Aachen University
D-52062 Aachen, Germany
Email: {schmitz, xu, schroeder, mathar}@ti.rwth-aachen.de

Index Terms—**SDR, Channel Emulator, GNU Radio**

***Abstract*— We present the design of a low cost Software Defined Radio Based Channel Emulator. The proposed system can be used to emulate channels for link level testing of any of type radio equipment. It comprises of one or multiple RF frontends at the input, respectively output side. Different channel models can be easily exchanged due to the software defined nature of the system. However, in this work we focus on a semi-stochastic, ray-tracing based urban channel model. The model combines advantages of a site specific physical model with a geometry based stochastic model. Being optimized for signal strength prediction and network planning, the ray-tracer is not able to simulate small scale effects like antenna diversity or doppler spread, yet the gap can be closed by the stochastic part of the model.**

I. Introduction

During the last years several freely available Software Defined Radio (SDR) frameworks have enabled researchers to develop a multitude of radio transmission systems and waveforms. However, the same technology can be applied for slightly different tasks or use cases. In this presentation we propose an SDR-based channel emulator using the GNU Radio framework [1]. This device can be used to emulate an RF channel in order to test a wireless transmission link. The system under test (SUT) could be any arbitrary radio equipment. During development a second SDR-based radio system serves as an exemplary SUT. The OFDM transceiver system has been used for a couple of cognitive radio demonstrations [2], [3] and has recently been extended to a 2x2 MIMO transmission mode.

The flexibility of the emulator is characterized by the reconfigurable number of parallel in- and output channels, while the different channel models can be easily emulated due to the software defined nature of the system. A 2x2 configuration of the channel emulator system is shown in Figure 1. Universal Software Radio Peripheral (USRP) devices are used to interface with the SUT. To allow for higher MIMO order channel emulation, the number of USRPs can be increased. The channel model used in the emulator system is based on a ray-tracing simulation of the radio propagation [4] combined with a stochastic model [5]. When running the system with the targeted semi-stochastic channel model, the online signal processing part is a relatively simple filter, which has to be updated with the channel impulse response generated in a preliminary offline phase.

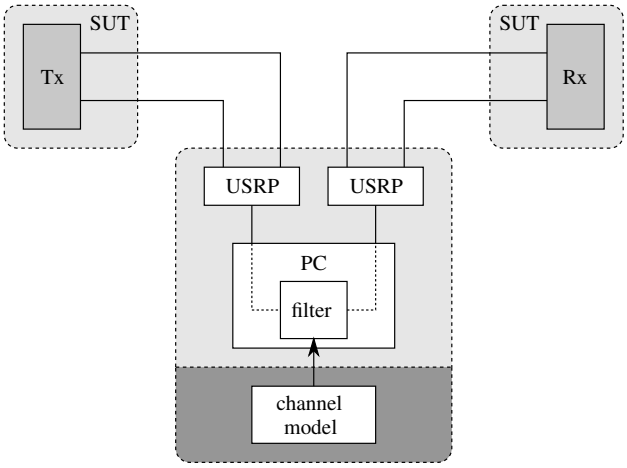

Fig. 1. System Architecture

A challenge lies in the conversion of the ray-tracer output into a suitable input format for the channel emulator. The ray-tracing simulation does not have a discrete sampling grid but rather the different paths arrive with arbitrary distances in the time domain. In order to be able to use the simulation output for the digital signal processing, it has to be remapped to a uniform sampling rate using an appropriate method. As described in [5], to generate the channel matrices $\mathbf{H}(t)$, the stochastic part of the model has to be applied to the simulation output.

References

[1] "GNU Radio," `http://gnuradio.org/`.
[2] Milan Zivkovic, Dominik Auras, and Rudolf Mathar, "OFDM-based Dynamic Spectrum Access," in *IEEE DySPAN 2010*, Singapore, Apr. 2010.
[3] Milan Zivkovic, Johannes Schmitz, and Rudolf Mathar, "Acquisition and Identification of OFDM Signals using Cyclostationary Signatures," in *ACM WiNTECH 2011*, Las Vegas, USA, Sept. 2011, pp. 91–92.
[4] Florian Schröder, Michael Reyer, and Rudolf Mathar, "Field Strength Prediction for Environment Aware MIMO Channel Models," in *6th European Conference on Antennas and Propagation (EUCAP)*, Prague, Czech, Mar. 2012, pp. 1–4.
[5] Xiang Xu, Michael Reyer, Florian Schröder, Alexander Engels, and Rudolf Mathar, "A Semi-Stochastic Radio Propagation Model for Wireless MIMO Channels," in *International Symposium on Wireless Communication 2011*, Aachen, Deutschland, Nov. 2011, pp. 619–623.

