A GNU Radio Based Receiver Toolkit for IEEE 802.11a/g/p

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ABSTRACT

We present an open source Software Defined Radio (SDR) receiver toolkit that is able to decode OFDM frames of IEEE 802.11a/g/p WiFi in real time. It is the first for GNU Radio that supports channel bandwidths of up to 20 MHz. The toolkit comprises the physical layer, decoding of MAC frames, and extracting the payload of IEEE 802.11a/g/p frames. It is further possible to access and visualize the data in every step of the decoding process in numerous ways. As an example demonstration, the impact of moving antennas and changing settings can be displayed live in time and frequency domain. Lastly, the decoded frames can be fed to Wireshark and/or received on a Linux network interface. Our receiver toolkit has been well received by the community and is already serving as the basis of further research.

1. DEMONSTRATION OF THE RECEIVER

The technical details of the implementation are described in [1]. There, we also present several interoperability tests and show that the receiver is compatible with both off-the-shelf WiFi cards and IEEE 802.11p prototypes designed for Vehicular Ad Hoc Networks (VANETs). The objective of this demo is to highlight the very straightforward use of the Orthogonal Frequency Division Multiplexing (OFDM) receiver and to show how its modular structure can be exploited to experiment with receive algorithms by simply exchanging modules of the receive chain with alternative implementations. Experimentation is further aided by the possibility to set up and configure the receiver in the GNU Radio GUI.

The setup of the demo is depicted in Figure 1. We send frames from an off-the-shelf WiFi card and receive them with the Universal Software Radio Peripheral (USRP). The WiFi card is based on an Atheros chipset and, with minor modifications of the Linux kernel (removing regulatory domain restrictions), we can use this card to send IEEE 802.11a/g/p frames, i.e., we can set the channel bandwidth to 10 MHz and 20 MHz and can tune to the 5.9 GHz band dedicated to Intelligent Transportation Systems (ITS).

In order to demonstrate the capabilities of the OFDM receiver, we extended it with various graphical outputs that visualize every step of the decoding process. In the time domain, we plot the raw complex base band signal as acquired from the Software Defined Radio (SDR) (cf. the plot on the top right of the inset in Figure 1). In the frequency domain, we show a constellation plot of the subcarrier symbols after compensation of channel induced phase rotations (cf. the bottom right plot of the inset in Figure 1). The QPSK-modulated symbols and the deviation from the ideal positions can clearly be seen. This plot supports an intuitive estimation of receiver performance, channel quality, and bit error rates.

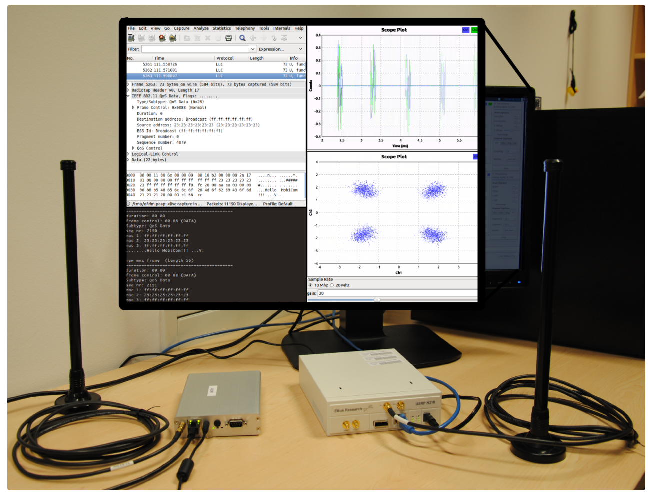

Figure 1: Photograph and screenshot of the setup.

To show that we can actually decode the payload, we output all frames in PCAP format, the de-facto standard for packet capturing, and connect Wireshark to it. In addition to that, we implemented the required blocks to connect the receiver with the Linux network stack. This can be done with the help of a TAP interface (i.e., a virtual Ethernet interface) and a block that replaces the WiFi headers with corresponding Ethernet headers. Thus, by setting up static routing and ARP entries on the sender, we can establish a unidirectional UDP communication between the WiFi card and the SDR.

To make the demo more interactive, we connect two large dipole antennas to the devices. This way, visitors can grab the antennas and move them around, watching the impact on the receiver. Accompanying this demo, we made a video that shows the setup and how visitors can interact. The video, a list of related publications, and all software can be found on our website.[1]

2. REFERENCES

[1] B. Bloessl, M. Segata, C. Sommer, and F. Dressler. An IEEE 802.11a/g/p OFDM Receiver for GNU Radio. In *ACM SIGCOMM 2013, 2nd ACM SIGCOMM Workshop of Software Radio Implementation Forum (SRIF 2013)*, Hong Kong, China, August 2013. ACM.

[1]`http://www.ccs-labs.org/software/gr-ieee802-11/`