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Bachelor's Thesis

A Real-Time LoWiLay Receiver on Commodity Wi-Fi Hardware

Abstract

At the edge of Wi-Fi coverage, an IoT device may still need to send a short sensor reading or an alarm. LoWiLay is a physical-layer overlay designed to provide a low-rate fallback in these conditions. The transmitter approximates LoRa-like chirps with a sequence of 802.11b CCK frames. The receiver recovers the payload from timestamped power spectra reported by a commodity Wi-Fi card. The simulations in the LoWiLay draft assume ideal spectral scanning without jitter or gaps.

In this thesis, you will characterize spectral scanning on selected Atheros Wi-Fi chipsets using the Linux `ath10k` driver and build a LoWiLay receiver that processes incoming scan reports in real time. A software-defined radio (SDR), such as a USRP, can serve as a reference transmitter for repeatable LoWiLay test signals. You will first measure how reliably the prototype decodes packets at different received power levels over a coaxial cable, then evaluate it in selected over-the-air scenarios.

Content

- **Measurement setup and reference signals**. Set up a 2.4 GHz testbed with a commodity Wi-Fi card and an SDR reference transmitter. Use known test signals to characterize the scanner and sequences of CCK frames that emulate LoWiLay chirps for end-to-end tests. Record the hardware models, firmware and driver versions, and scan settings.
- **Spectral scan characterization**. Measure the effective scan rate, the intervals between successive reports, and their variation (jitter). Identify gaps in time and missing or unusable FFT bins in the frequency range used by LoWiLay. Where the available timestamps and a suitable time reference permit, measure the delay from spectrum capture to report availability in the host process. Document the time reference and measurement uncertainty.
- **Real-time receiver**. Implement the receive chain for one LoWiLay profile with a four-byte payload. Continuously read and buffer scan reports, detect packet starts, estimate carrier frequency offset (CFO), classify chirps with a convolutional neural network (CNN), and recover the payload using Reed–Solomon decoding and a cyclic redundancy check (CRC). Verify that the receiver keeps up with incoming reports without a growing backlog. Measure the latency to decoded payload delivery.
- **Coaxial and over-the-air evaluation**. Use adjustable attenuation in the coaxial setup to measure packet delivery ratio (PDR) as a function of received power. Check the recovered sequence numbers and payloads against the transmitted data to determine which packets were delivered correctly. Repeat the measurements in selected over-the-air scenarios, for example with and without line of sight. Use the scan and receiver logs to assess how jitter and gaps affect packet detection and decoding.
- **Deliverables**. Provide a runnable receiver prototype, the measurement and analysis scripts, the data used in the analysis, and instructions for reproducing the experiments.

Requirements

- Basic knowledge of wireless communication and digital signal processing, especially FFTs and spectrograms
- Good programming skills in Python or C/C++ and confidence working with Linux
- Interest in hands-on laboratory work and systematic analysis of measurement data
- Experience with SDRs or USRPs, Wi-Fi drivers, or neural networks is a plus

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