

LoRa Signal Analysis

Master's Thesis

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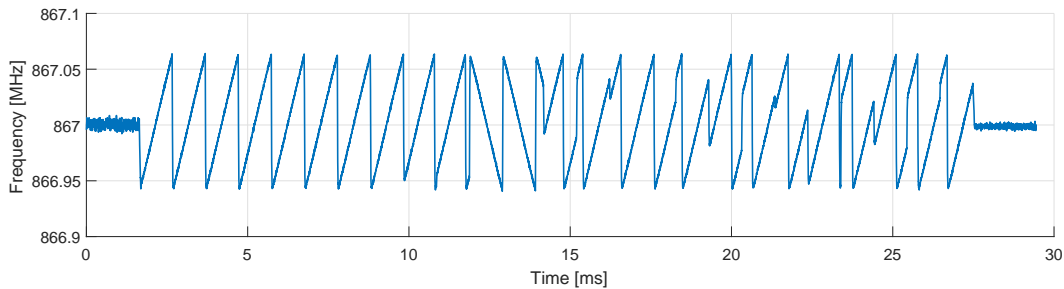
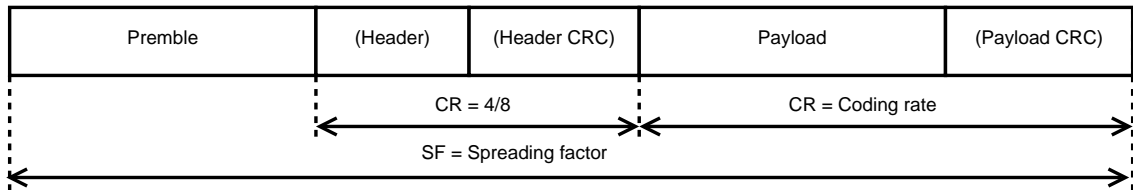
4. 6. 2019

- Describe basic principles of LoRa communication protocol and LoRaWAN MAC layer
- Design a LoRa demonstrator with suitable wireless modules
- Capture RF communication using SDR, identify the LoRa signal
- Design a sniffer for LoRa protocol analysis
- Identify LoRaWAN network traffic and evaluate its basic usage in Brno

- Proprietary technology by Semtech
- Long range
- Low power
- Low transfer rate
- Spread spectrum
 - Demodulation below noise floor
 - Resistant to multipath propagation
 - Resistant to Doppler effect
- Works in ISM bands
- Spreading factor SF6 - SF12
- Coding rates 4/5, 4/6, 4/7, 4/8
- Bandwidth from 7.5 kHz to 500 kHz



LoRa packet

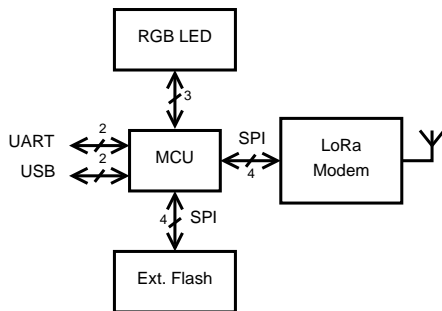


- Media Access Control (MAC) protocol
- Supervised by LoRa Alliance
- Specification publicly available
- Robust AES security
- 3 classes of devices
- Commercial provider in CZ: Ceske Radiokomunikace
- Estimated coverage 75% of CZ
- To be used in IoT



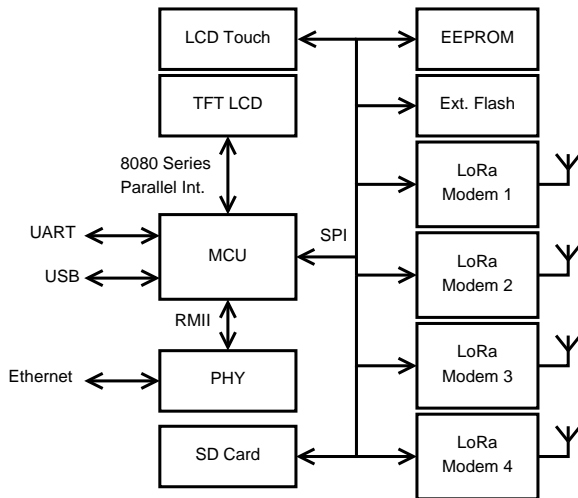
LoRa USB Dongle

- Power and control from USB
- Size of a Flash Drive
- NXP LPC111U68
 - 256 kB Flash
 - 32 kB RAM
 - 4 kB EEPROM
- LoRa Modem: RFM95W
- External Flash memory
- RGB LED
- Firmware in C, features:
 - LoRa Modem configuration
 - Wireless communication test
 - Receiving and transmitting of text messages
 - Change LED color



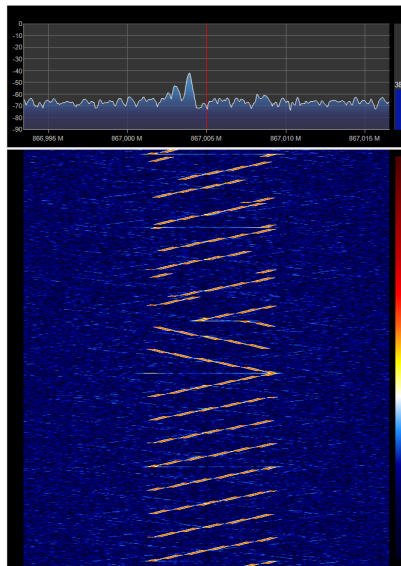
LoRa Multiciever (Sniffer)

- Parallel listening on 4 configurations
- TFT LCD touchscreen
- SD card for data logging
- USB, Ethernet
- Power supply 5 - 25 V
- 4x LoRa Modem RFM95W
- STM32F439
 - 2 MB Flash
 - 256 kB RAM
 - up to 180 MHz
- Firmware in C, features:
 - LoRa Modem configuration
 - Store received packets to SD
 - LoRaWAN packets decoding
 - Automatic scanning of predefined bands and SF
 - Supervision over Telnet



LoRa signal

- Captured with RTL-SDR
- BW: 7.5 kHz
- SF: 12
- CR: 4/8
- Saved and processed in MATLAB



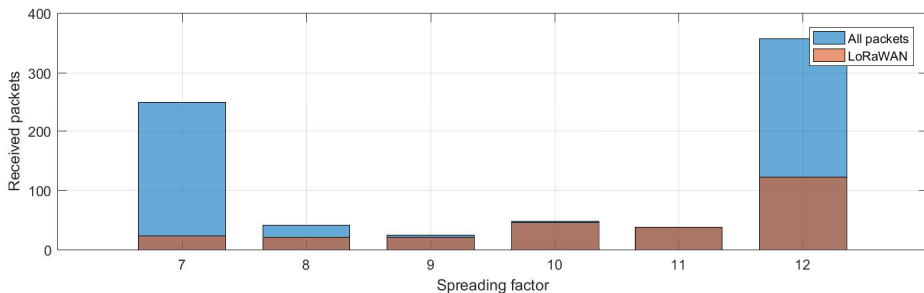
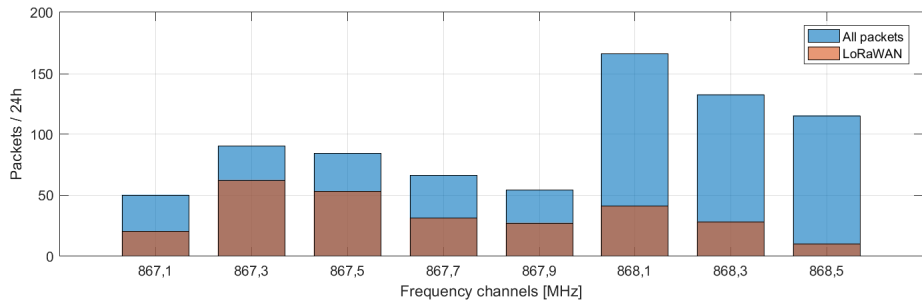
- Placed at SE6.125 behind the window (1st week)
- Placed on the roof in a box (2nd week)
- LoRa channel scan in 867.1 - 868.5 MHz range
- SF7 - SF12
- Saving data to SD card
- Decoding of LoRaWAN packets
- Processing in MATLAB



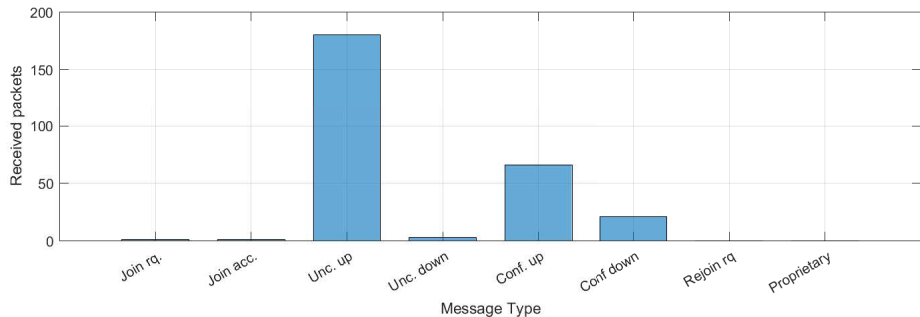
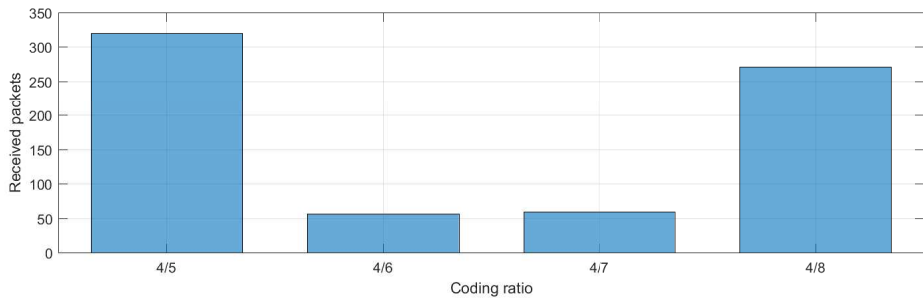
Data captured sequentially for 2 weeks, converted to continual traffic of 1 day:

Total packets	1057
Packets with valid CRC	758
Packets with invalid CRC	299
LoRaWAN packets	272
Other packets	486
Unique LoRaWAN devices	47
Most common SF	12
Most common CR	4/5
Average signal strength	-117.5 dBm
Average signal SNR	-6.6 dB
Average payload length	55 B

LoRaWAN in Brno: Frequency channels and Spreading Factor



LoRaWAN in Brno: Coding Ratio and message types



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