HNAP
The HAMNET Access Protocol

DESIGN OF A RADIO COMMUNICATIONS PROTOCOL FOR HAMNET ACCESS IN THE 70CM AMATEUR RADIO BAND

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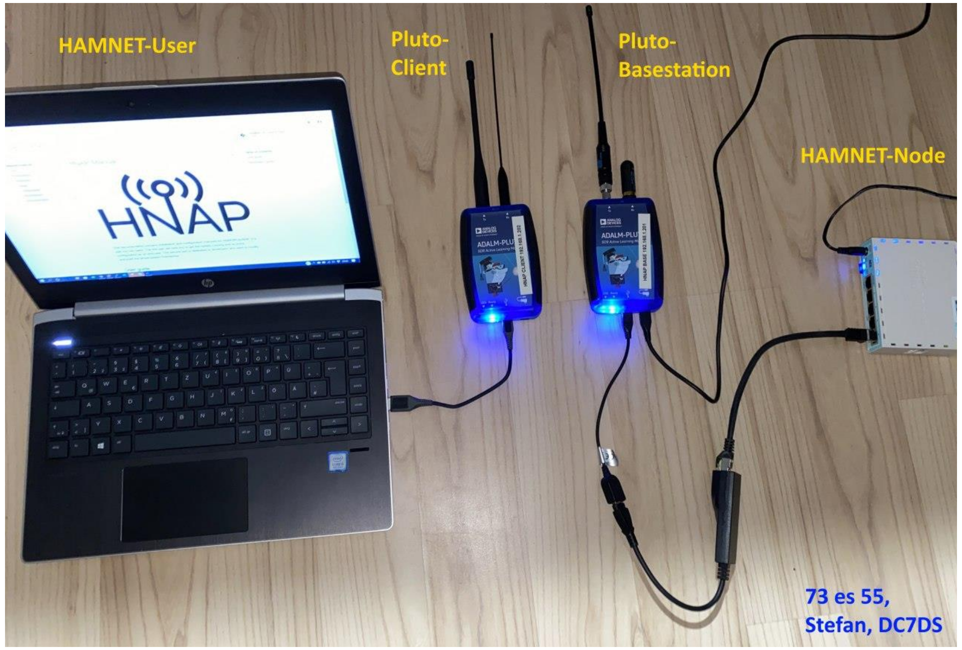


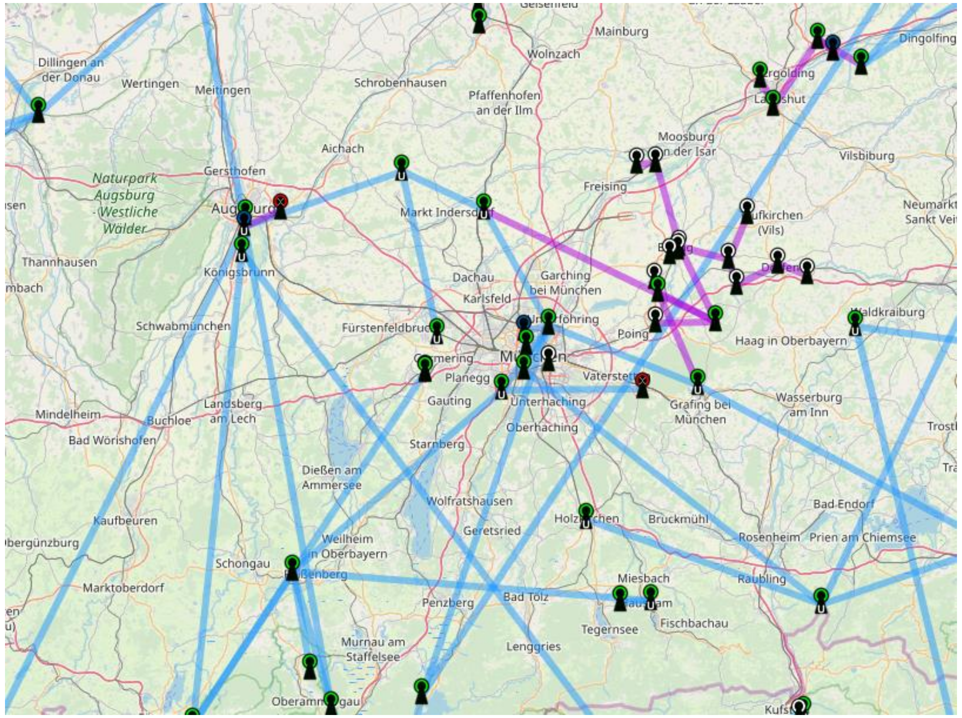
About Hamnet

Highspeed AmateurRadio Multimedia Network

IP Network separated from Internet

Directional radio link at 2.4GHz and 5.7GHz

Problem: Access requires line of sight to HAMNET station



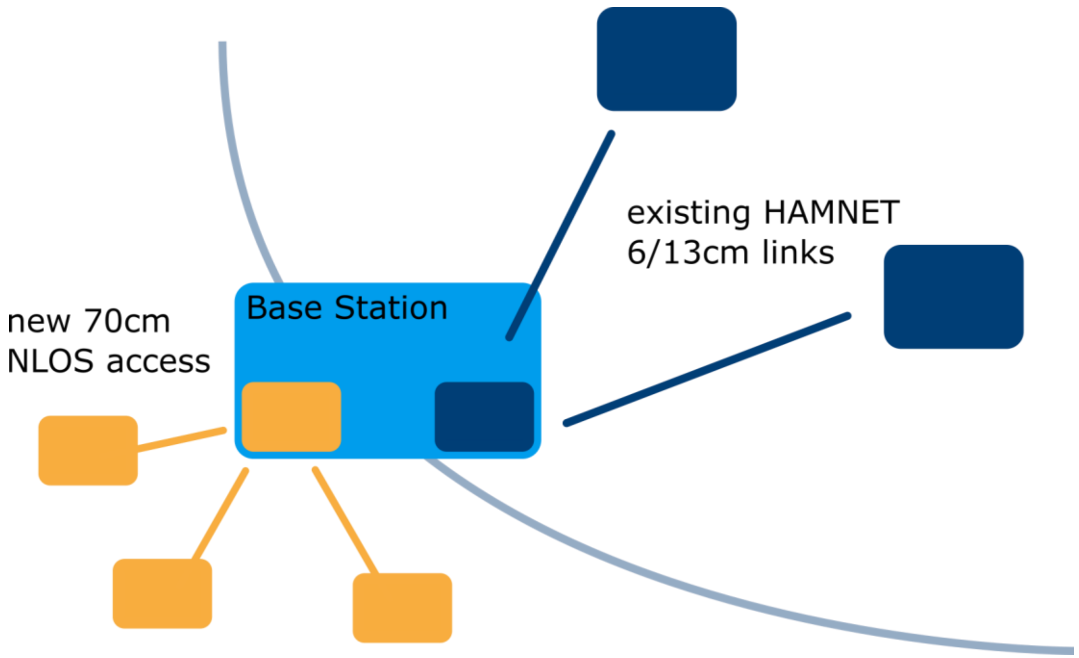
www.hamnetdb.net

Thesis Motivation

Enable the use of 200kHz duplex channel at 439,7MHz UL / 434,9MHz DL

Provide NLOS access to HAMNET backbone

Extend Network Coverage



System Requirements

VoIP capable: full stack delay <150ms

Adaptive data-rates, higher than existing solutions: >130kbps

Flexible design: scale to other bandwidths

Cheap Hardware

- Basestation <1000€ / client <300€
- Client: only half-duplex

System Overview

OFDM system with 4 kHz subcarrier spacing

- 40 modulated carriers → 160 kHz system bw

16 µs Cyclic Prefix to combat ISI

FDD/TDMA structure: slot as smallest resource unit

Modulation: QPSK – QAM256

Convolutional coding

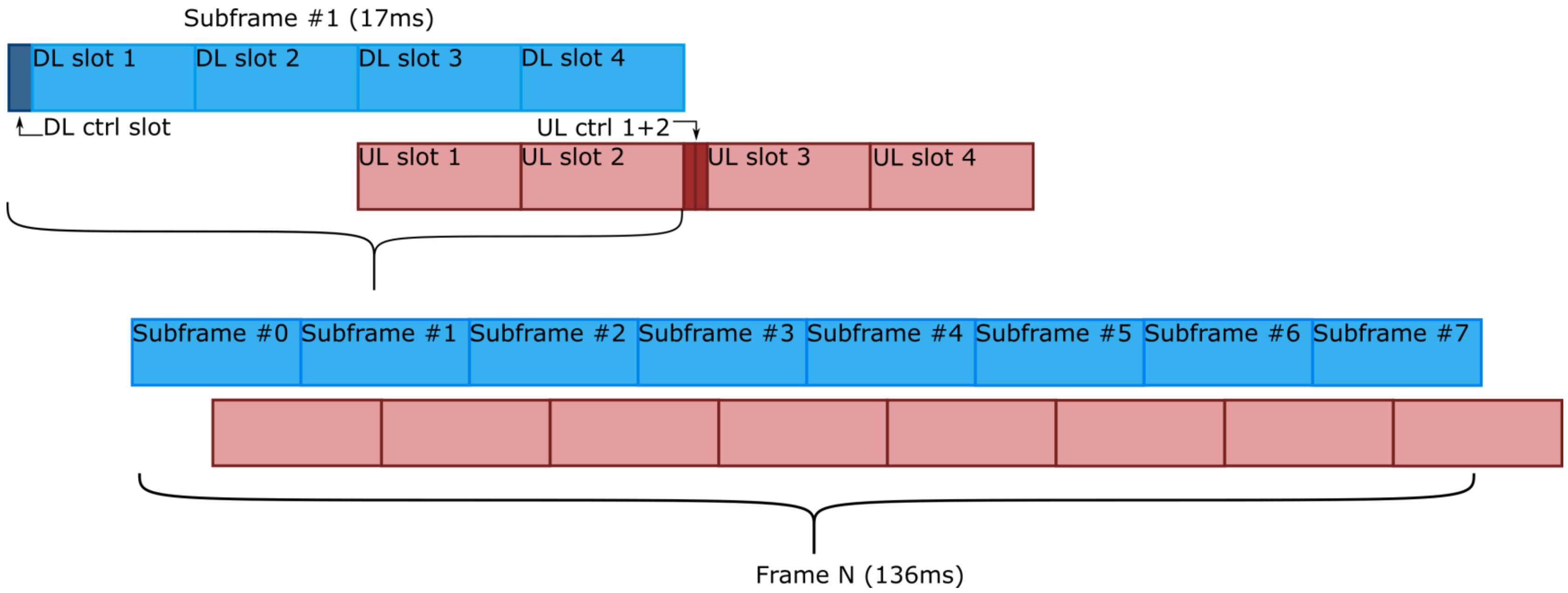
MCS idx	Modulation	Coding-rate
0	QPSK	½
1	QPSK	¾
2	QAM16	½
3	QAM16	¾
4	QAM64	½
5	QAM64	¾
6	QAM256	½

Frame Structure

One Subframe (17ms) contains 4 UL and 4 DL data slots

Control Slot in Downlink defines slot assignments

Uplink control slot for resource requests



MAC Layer

At most 14 Users

Accepts Ethernet frames as payload (can use ARP, DHCP, Network bridge from OS).

Users see network as one Ethernet switch

Supports Fragmentation (max 1900bytes frame size)

Round-robin scheduler, scheduling period: 17ms

Unacknowledged mode (ARQ supported but not yet implemented)

Adalm Pluto SDR

Analog Devices AD9363 transceiver

1 RX + 1 TX channel

Tuning range: 325MHz – 3.8GHz

Xilinx Zynq-7000 SoC

- 667MHz ARM Cortex-A9 dualcore
- Small FPGA

512MB RAM

Cost: ~150€

wiki.analog.com

Application overview

Written in C using liquid-dsp library

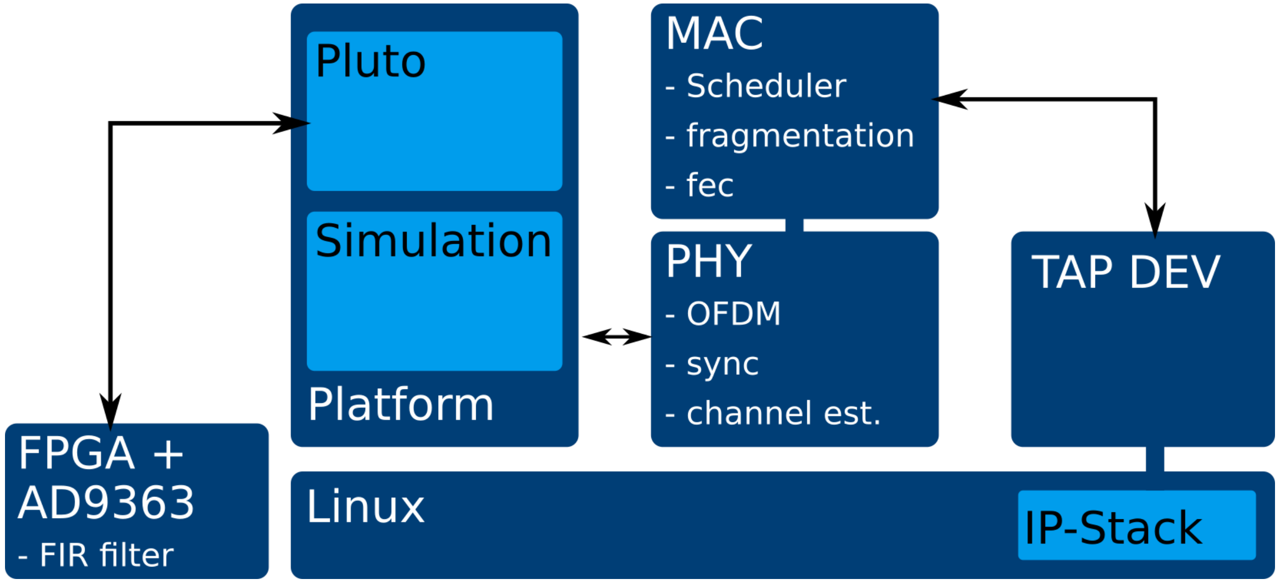
Abstract platform interface

- Simple integration of a simulation environment

TAP device is exposure point to

Linux Network stack

- Ethernet transparency



Achieving Realtime Execution

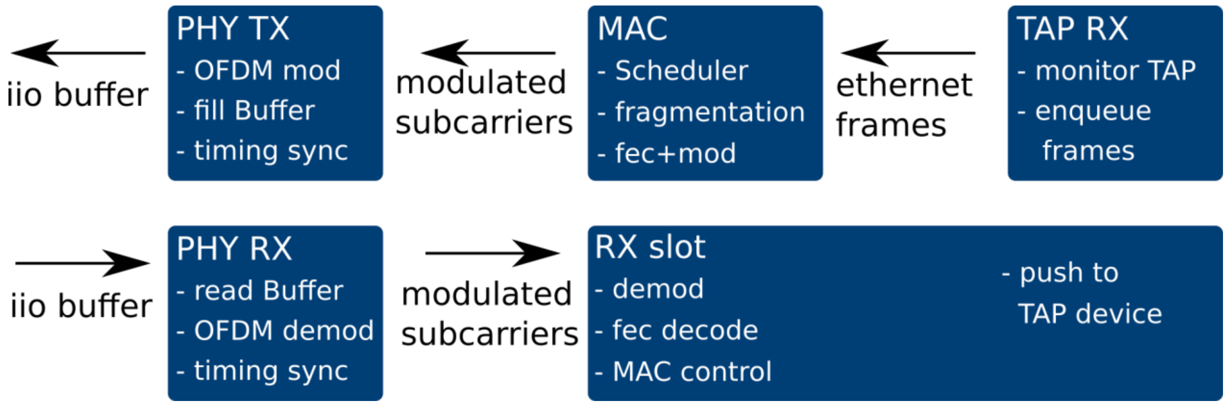
Use Linux RT-patch and Linux realtime priorities

Use pthreads and distribute load across CPU cores

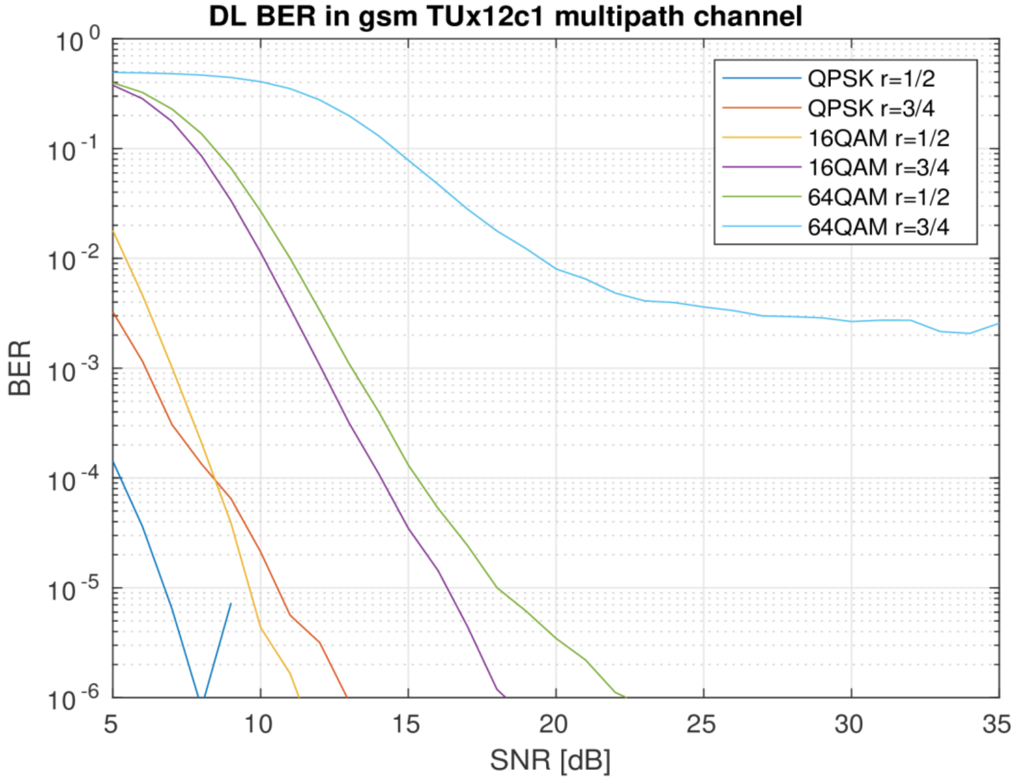
Use isolated core for buffer transfers

ARM Neon optimized Viterbi decoder (3x speedup)

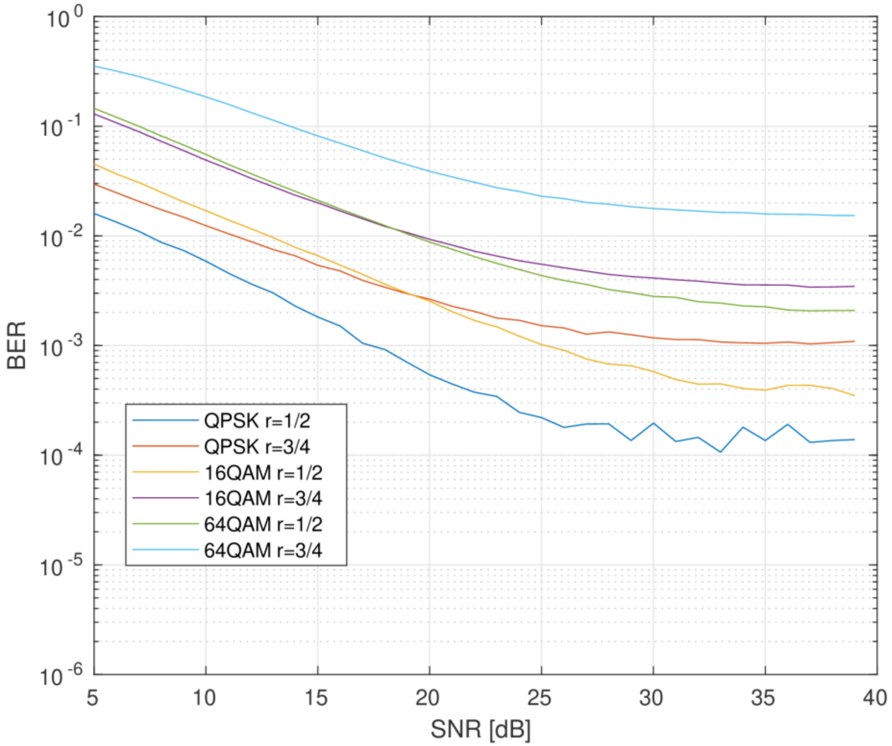
- Ported from libfec SSE2 decoder



BER Simulation



Static multipath channel



Rayleigh fading channel

System Demo

lukas@lukas-VN7: ~

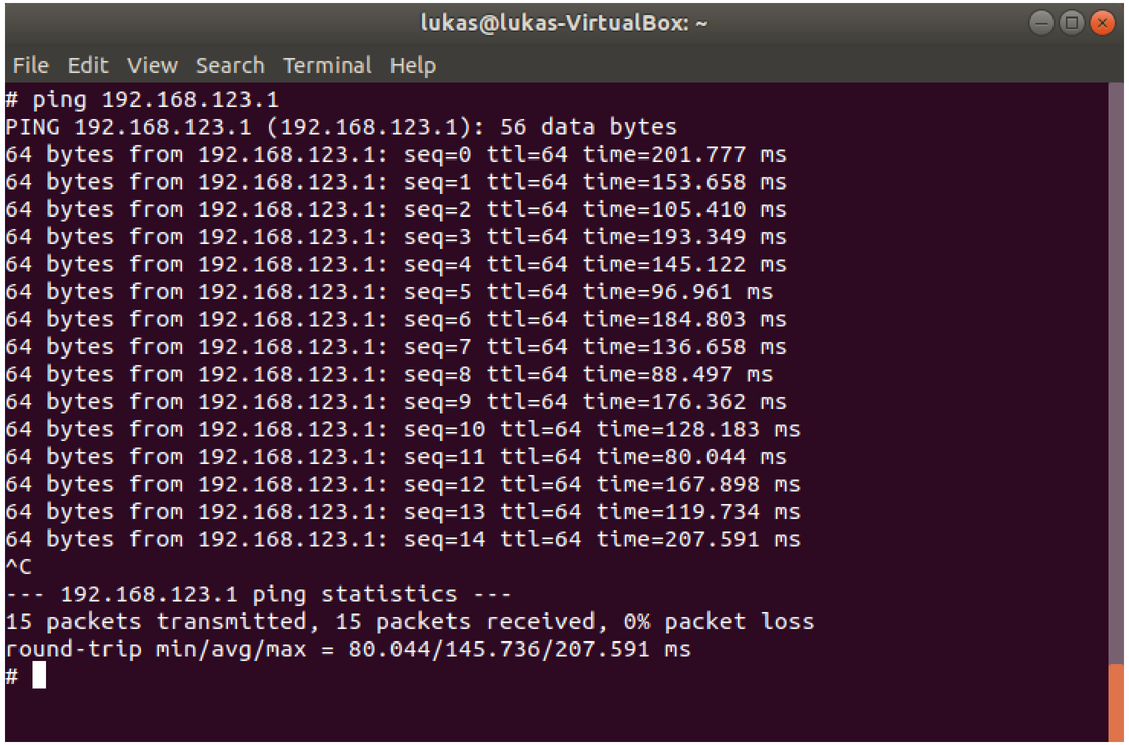
Datei Bearbeiten Ansicht Suchen Terminal Hilfe

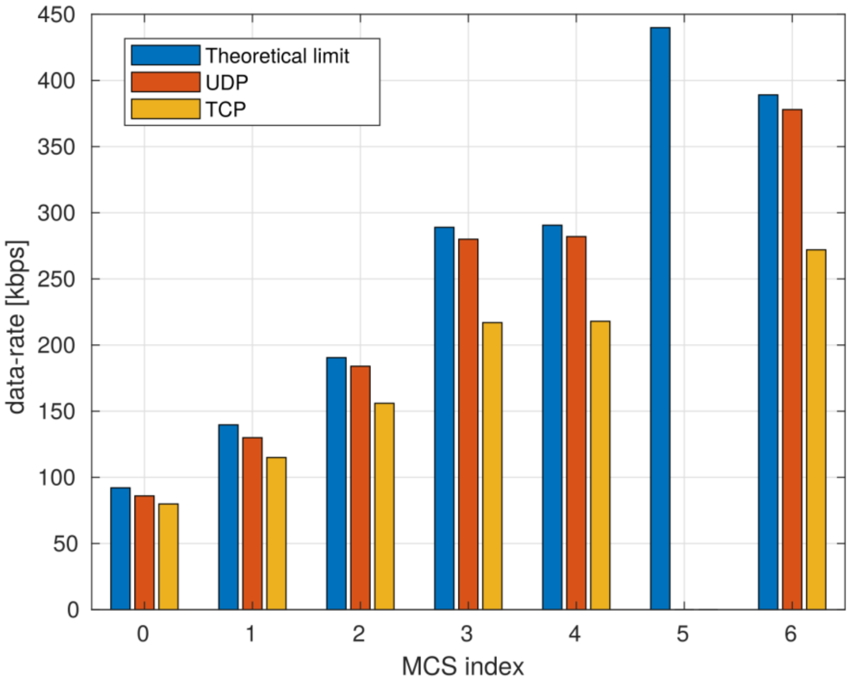
```
# ifconfig
lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:8 errors:0 dropped:0 overruns:0 frame:0
          TX packets:8 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:680 (680.0 B)  TX bytes:680 (680.0 B)

tap0      Link encap:Ethernet  HWaddr 8A:E6:01:FE:2B:8F
          inet addr:192.168.123.4  Bcast:192.168.123.255  Mask:255.255.255.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:1363 errors:0 dropped:0 overruns:0 frame:0
          TX packets:901 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:1895903 (1.8 MiB)  TX bytes:64579 (63.0 KiB)

usb0      Link encap:Ethernet  HWaddr 00:05:F7:7C:9F:6F
          inet addr:192.168.4.1  Bcast:0.0.0.0  Mask:255.255.255.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:2110 errors:0 dropped:19 overruns:0 frame:0
          TX packets:1997 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:125802 (122.8 KiB)  TX bytes:442885 (432.5 KiB)
```

System Demo





Throughput measurements

Conclusion

Built a 200 kHz communication system with high spectral efficiency

Short scheduling period at MAC layer makes VoIP support possible

Combining simulation and production code sped up implementation process

TODO:

- Test system with power amplifier over larger distances
- Implement ARQ scheme

Further reading

www.hnap.de

www.github.com/HAMNET-Access-Protocol/HNAP4PlutoSDR