Turn-Key PHY/MAC Designs (and other applications)

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Special Thanks to:

YOU!
YOU!
YOU!

Overview

- Overview of Existing Projects
- Where to go for working examples/applications
- gr-mac – an open source MAC project
- (In-Tree OFDM Implementation)

In-Tree Modules and Examples

- Audio Examples → gr-audio/examples
  - Dual tone generation
  - Audio FFT, Resampling and More
  - Python/C++/GRC

- Lots of Examples → gr—uhd/examples/
  - USRP-specified examples
  - FM/AM/Weater receivers and PTT trasmitters
  - Digital/PSK examples
  - uhd_fft

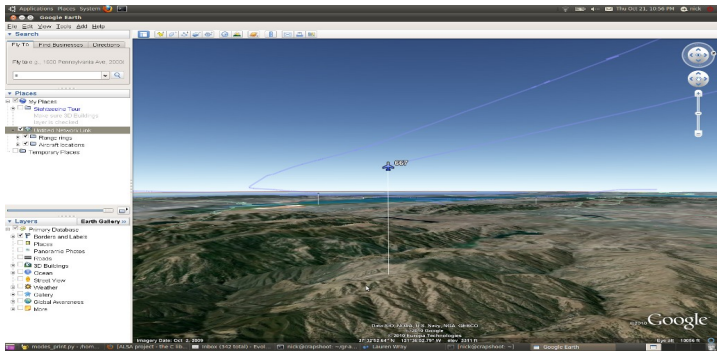
- Digital TV Reception → gr-dtv/examples
  - ATSC (US)
  - DVB-S/T/S2/etc coming soon!

- Digital Communications (mostly mPSK) → gr-digital/examples/

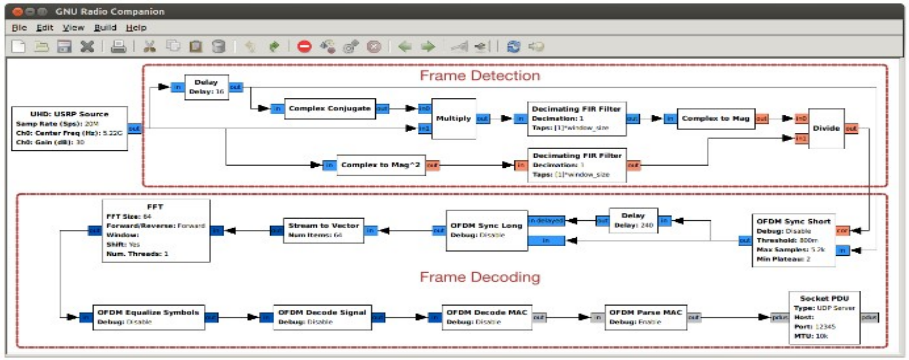
- Many other in-tree modules → gr-fec, gr-fft, gr-filter

CGRAN and Out-Of-Tree Modules

- https://www.cgran.org
- Large variety of open source projects
- A great place to get started with cool applications in a matter of a few minutes!



- gr-air-modes
- Receive aircraft RADAR beacons and plot in Google Earth!

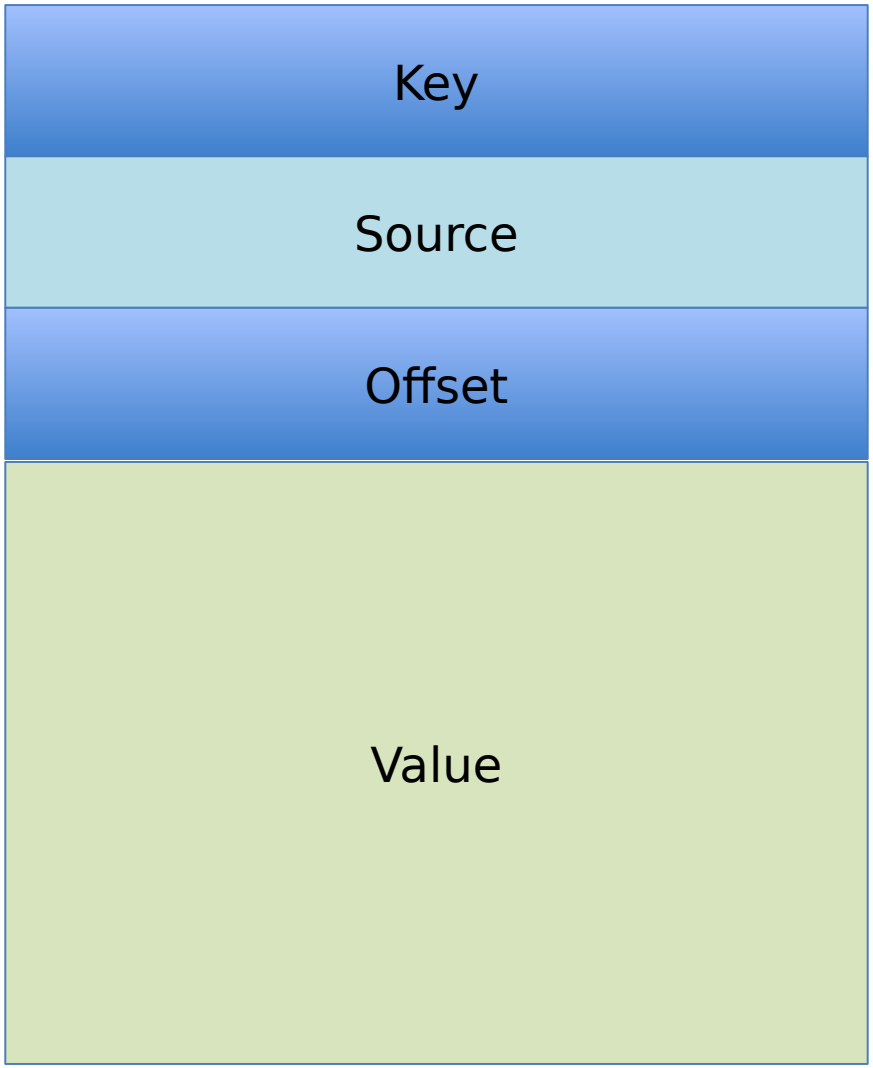


- gr-ieee802-11
- Full function 802.11 a/g/p receiver

A Few Important Concepts

- Shown several time throughout the week
- Important Features/Concepts
  - Samples vs. Polymorphic Types
  - Stream Tags
  - Message Passing API
  - PDUs
  - Advanced Hardware Support
  - C++ vs. Python Blocks

Polymorphic Data Types



Type: String
Used by blocks to identify PMT

Type: String
Specifies origin(block) of PMT

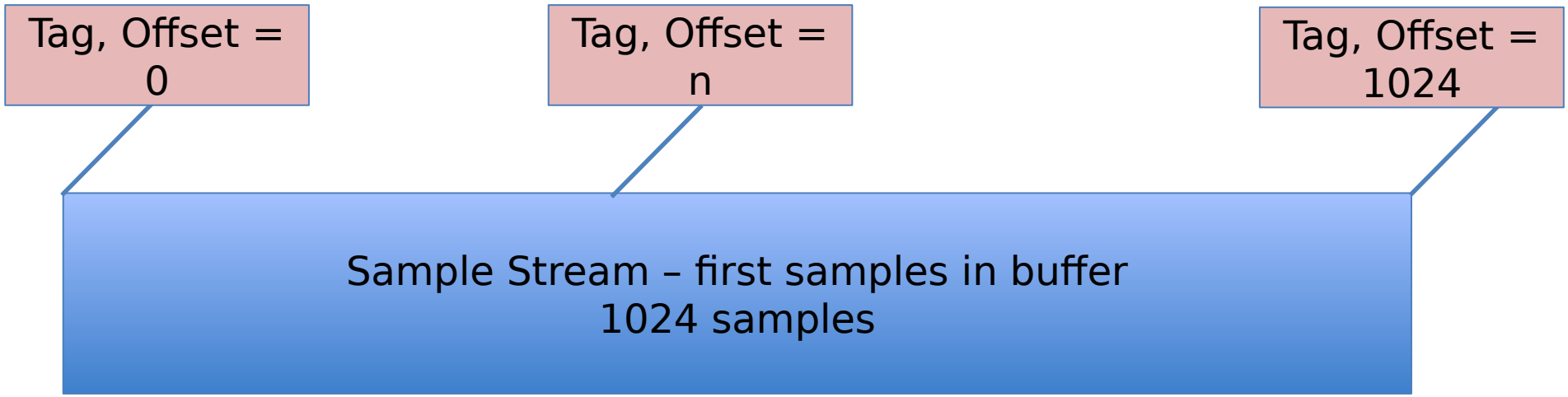
Type: Int
Specifies sample position

Type: Can by many types
“payload data”

Int, String, Bool, PDU, etc.

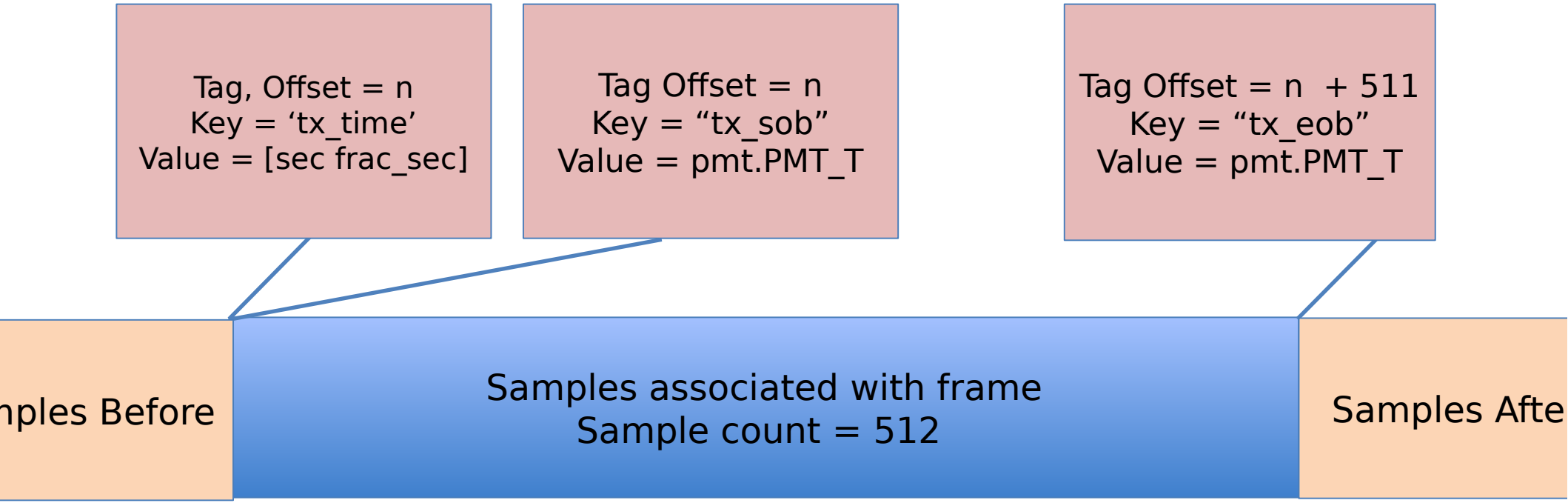
Stream Tags

- Tags – PMTs that are inserted into a GNU Radio sample stream
- PMT assigned absolute offset, tagging a specific sample
- Useful for synchronizing block functionality to DSP/samples
- Examples: UHD Sink understands tx_sob, tx_time, tx_eob tags



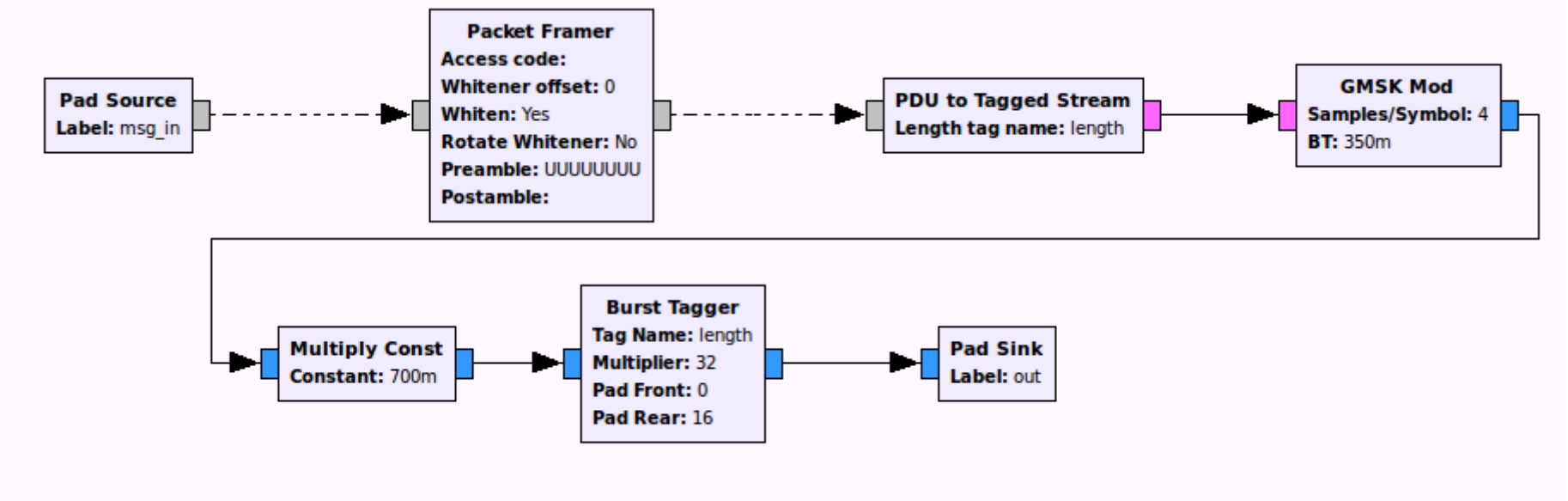
Half-Duplex/Bursting with Stream Tags

- Specifies time of burst, start of burst, and end-of-burst
- Useful for half-duplex systems that require tight control over tx/rx functionality

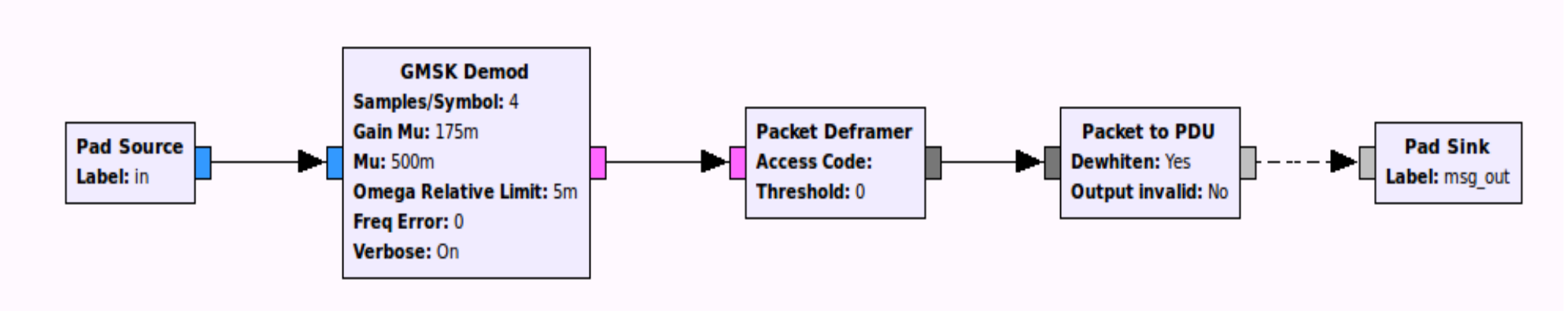


Tagged Stream Blocks

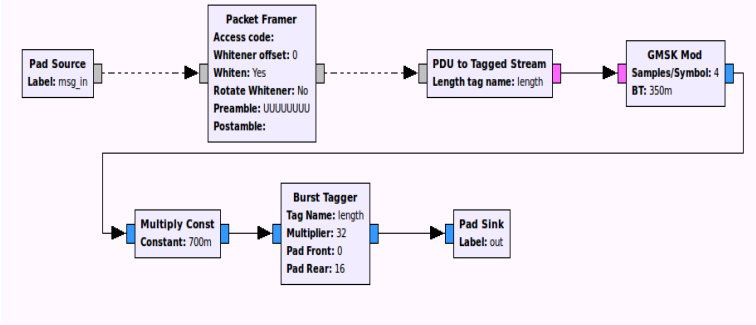
A Simple Transmitter

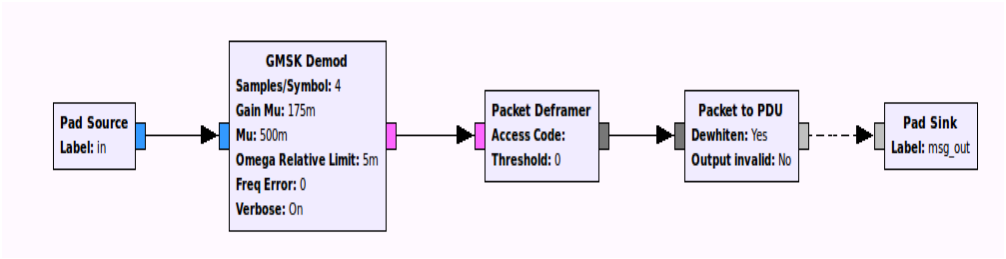


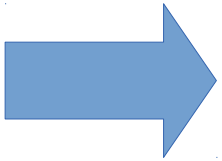
A Simple Receiver

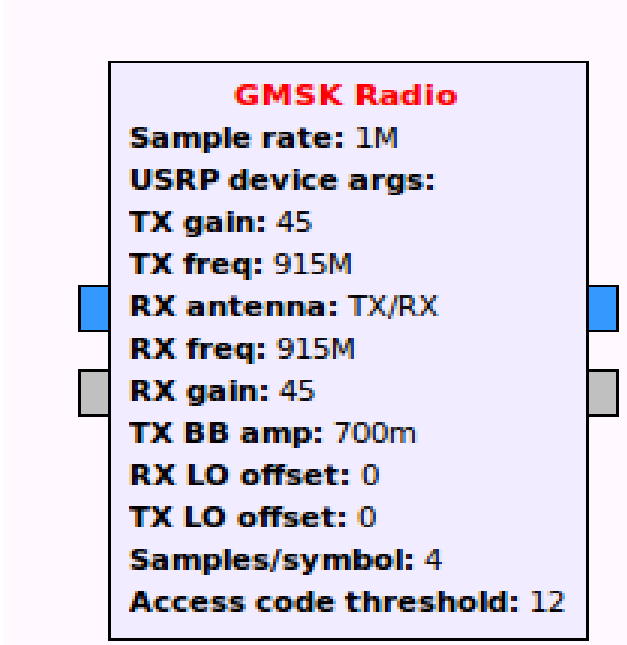


A Hierarchal Block

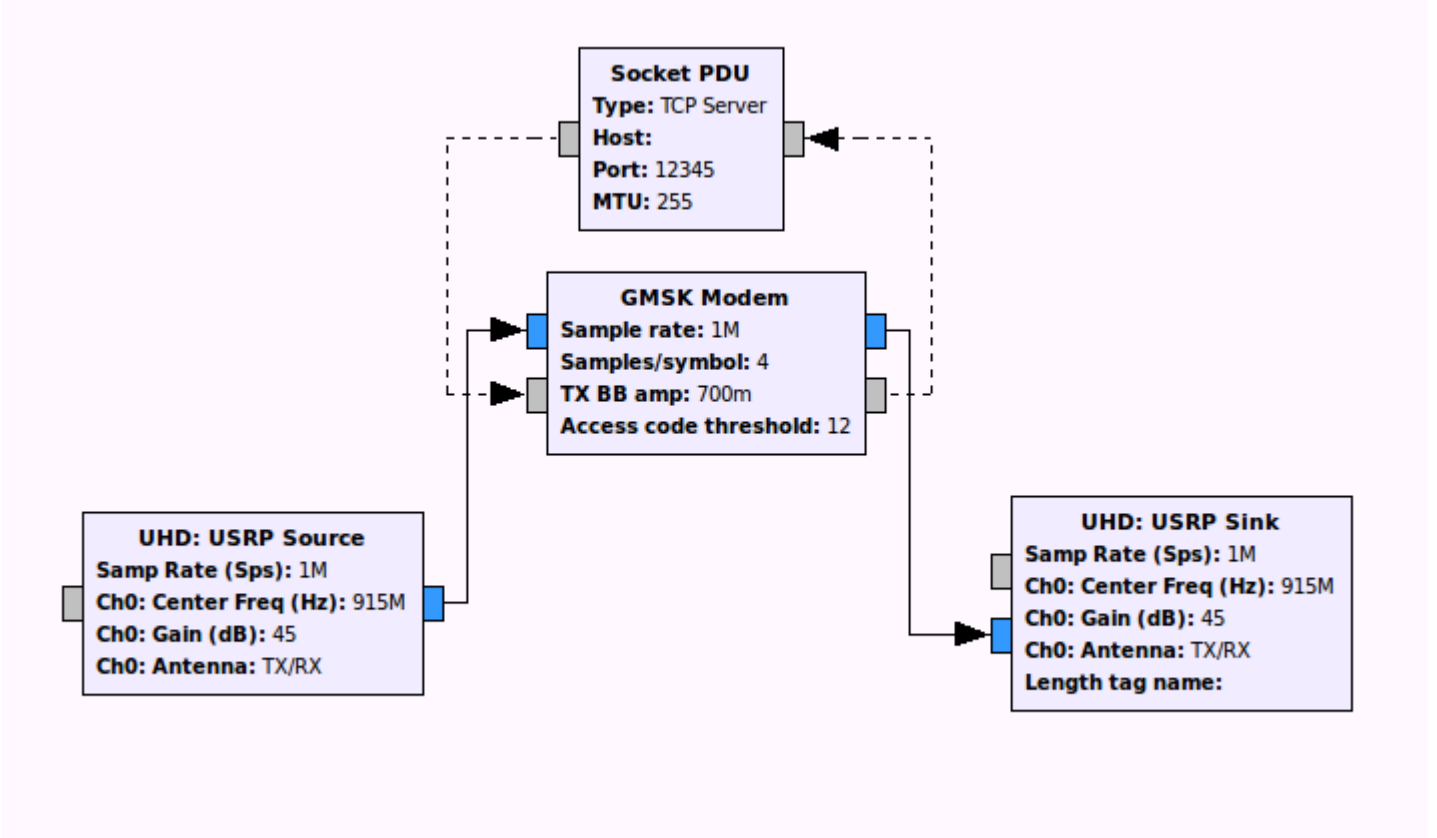




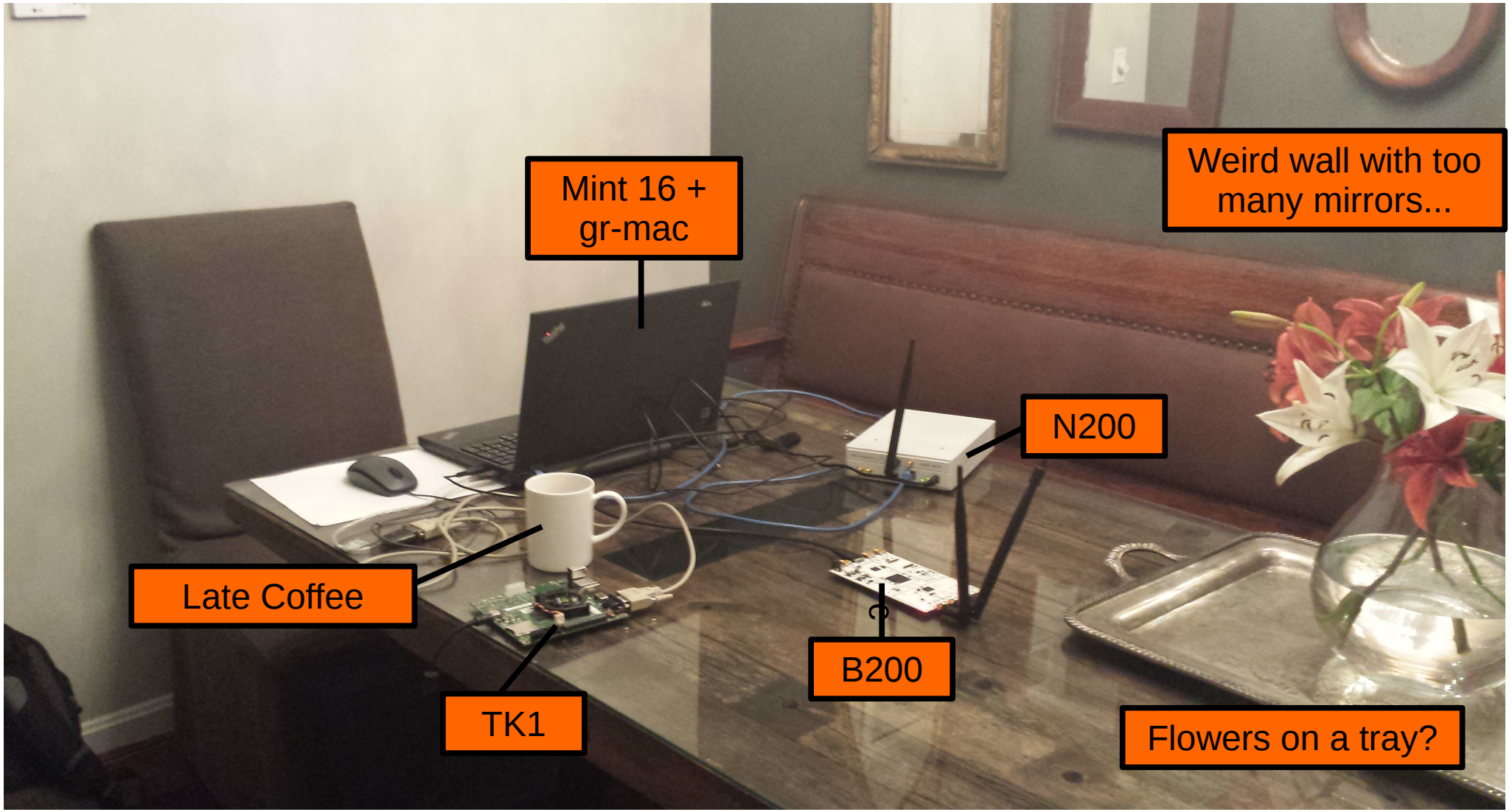




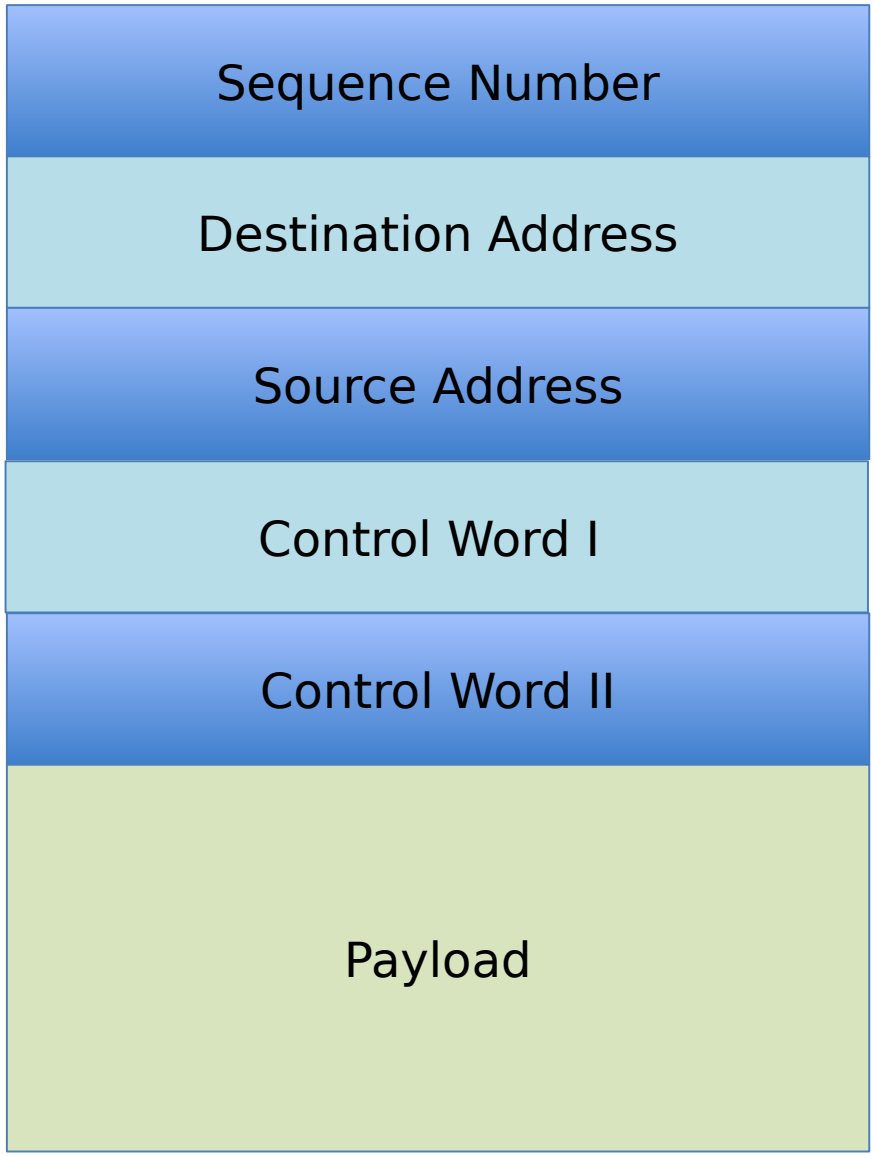
A Simple Transceiver



Late-Night Demo Prep/Recording



MAC Frame



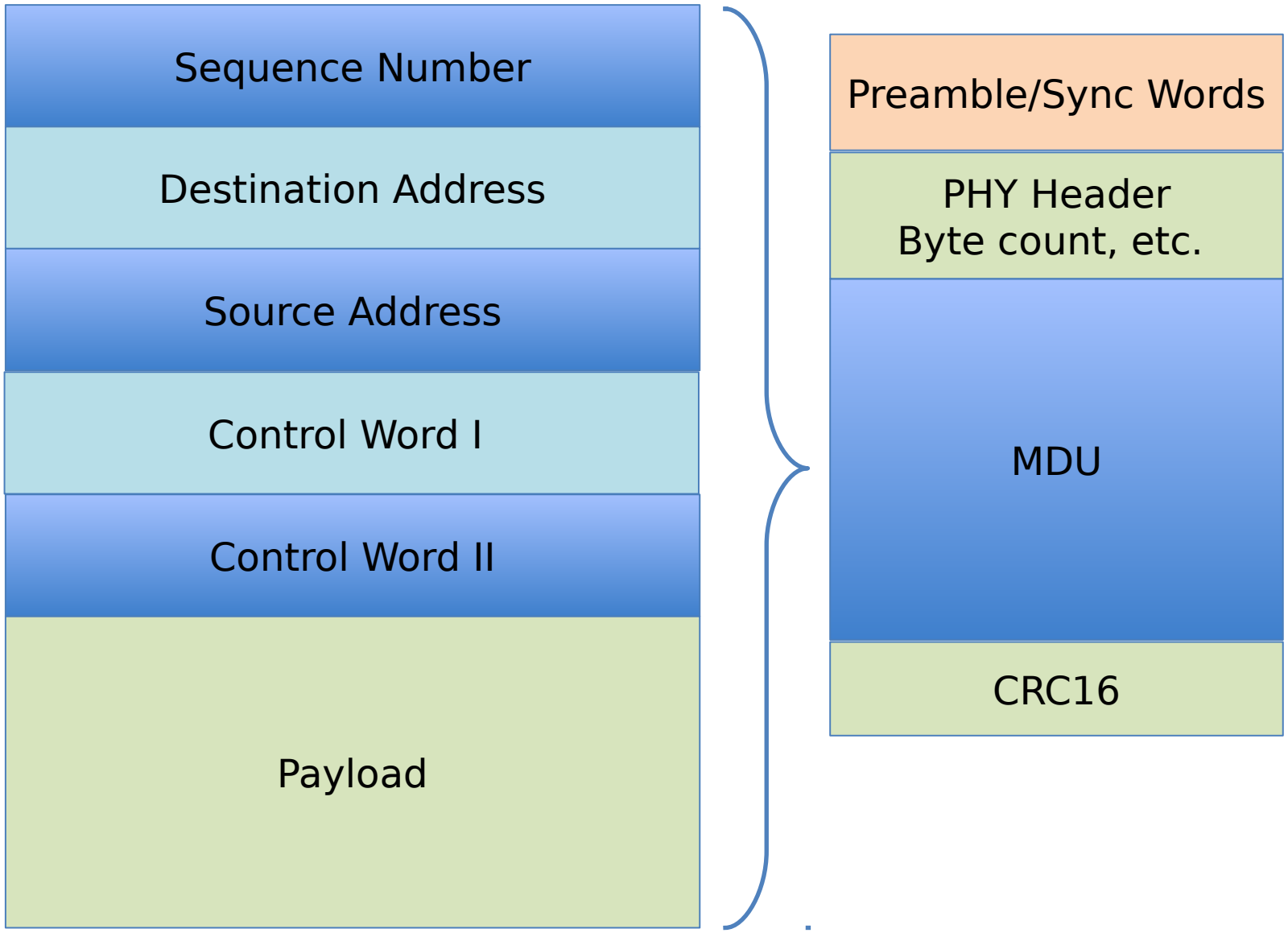
Sequence Number for ARQ and dropped-frame detection

Address of radio we're sending this msg to.

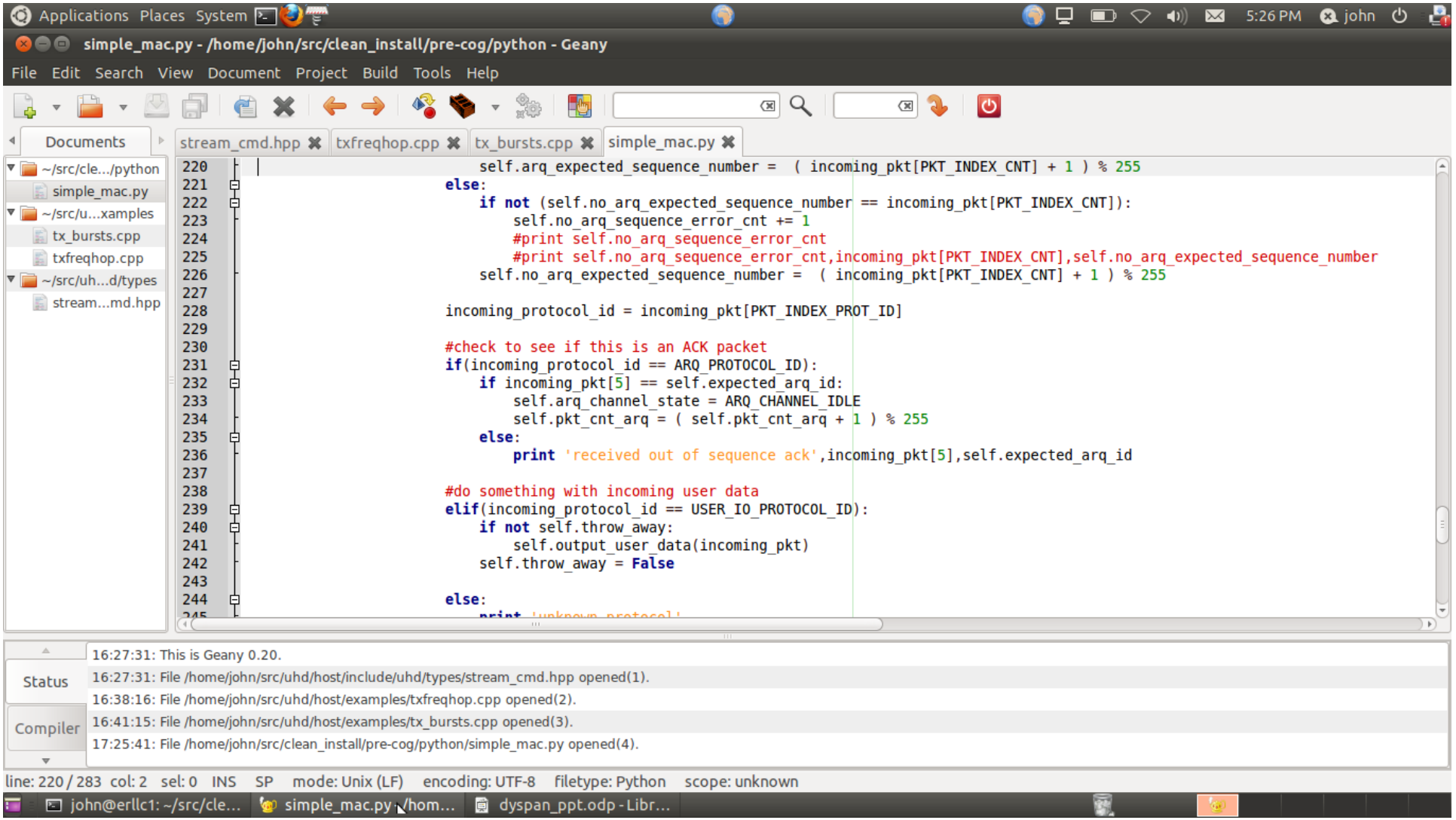
Radio's address ("my address")

Control words: settings include ARQ, protocol id, FEC settings, etc.

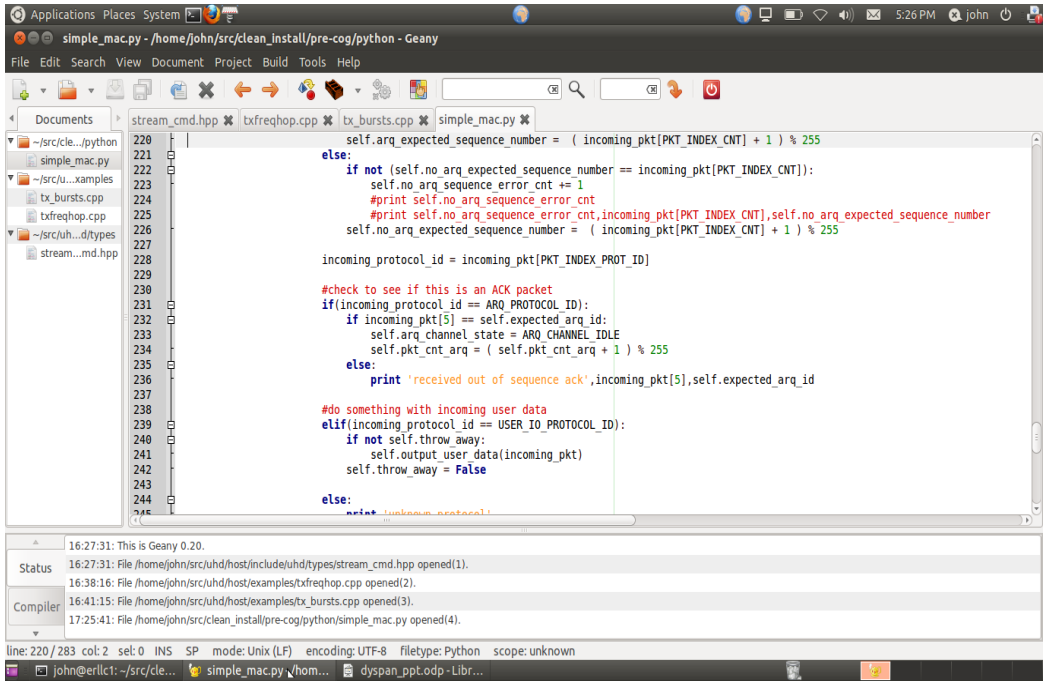
This is our payload, it can be represented as a "blob" and is in our implementation

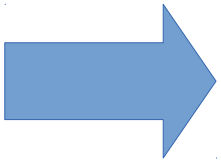

Sequence Number
Destination Address
Source Address
Control Word I
Control Word II
Payload
Preamble/Sync Words
PHY Header
Byte count, etc.
MDU
CRC16

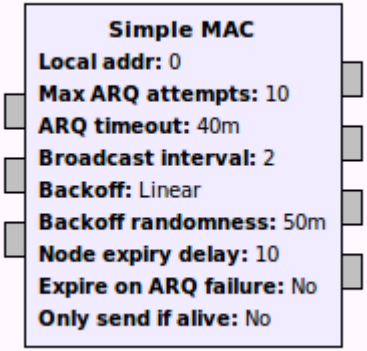
A Simple Transceiver (simple_trx.py)



Python-Defined MAC Layer





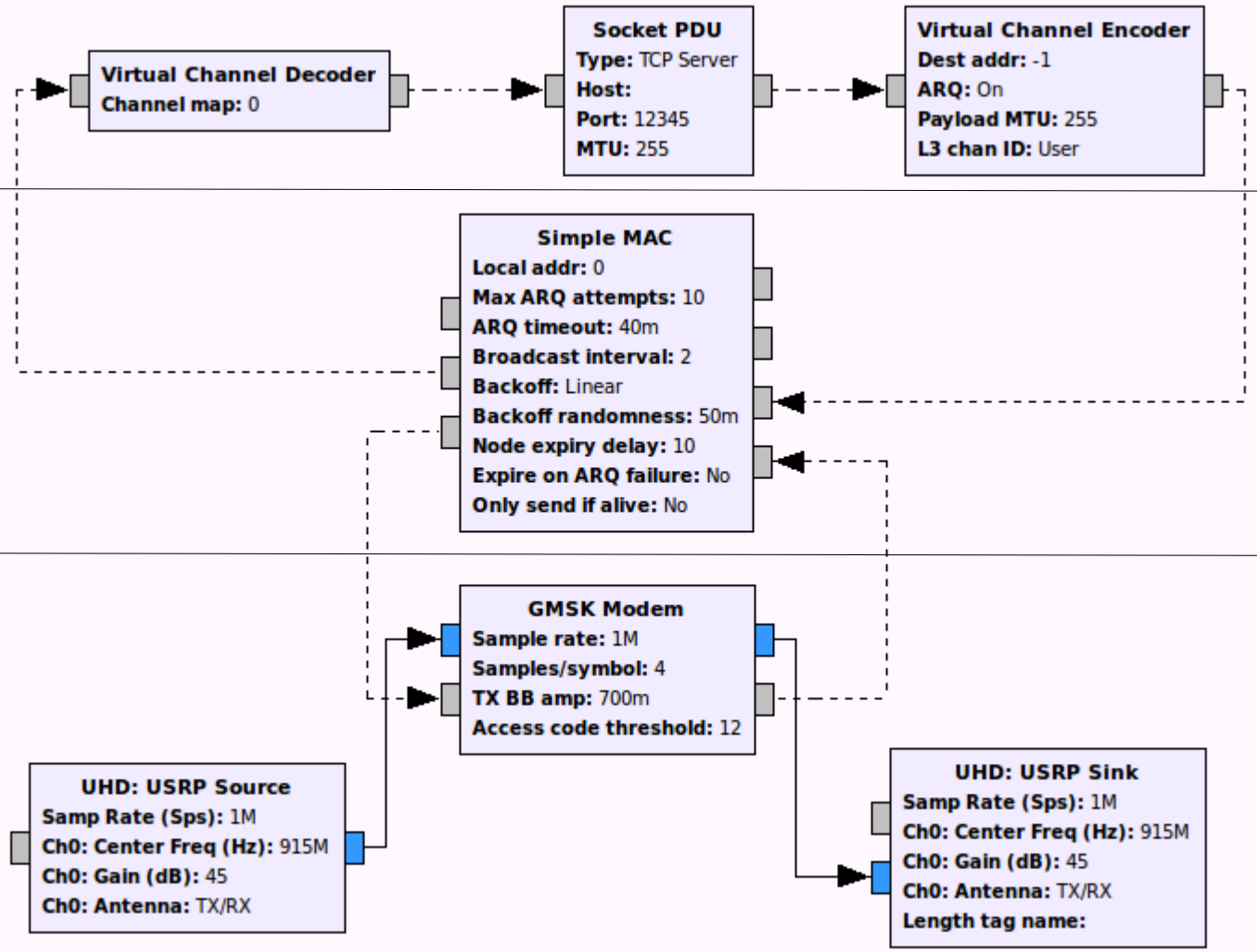


Adding MAC to the Transceiver

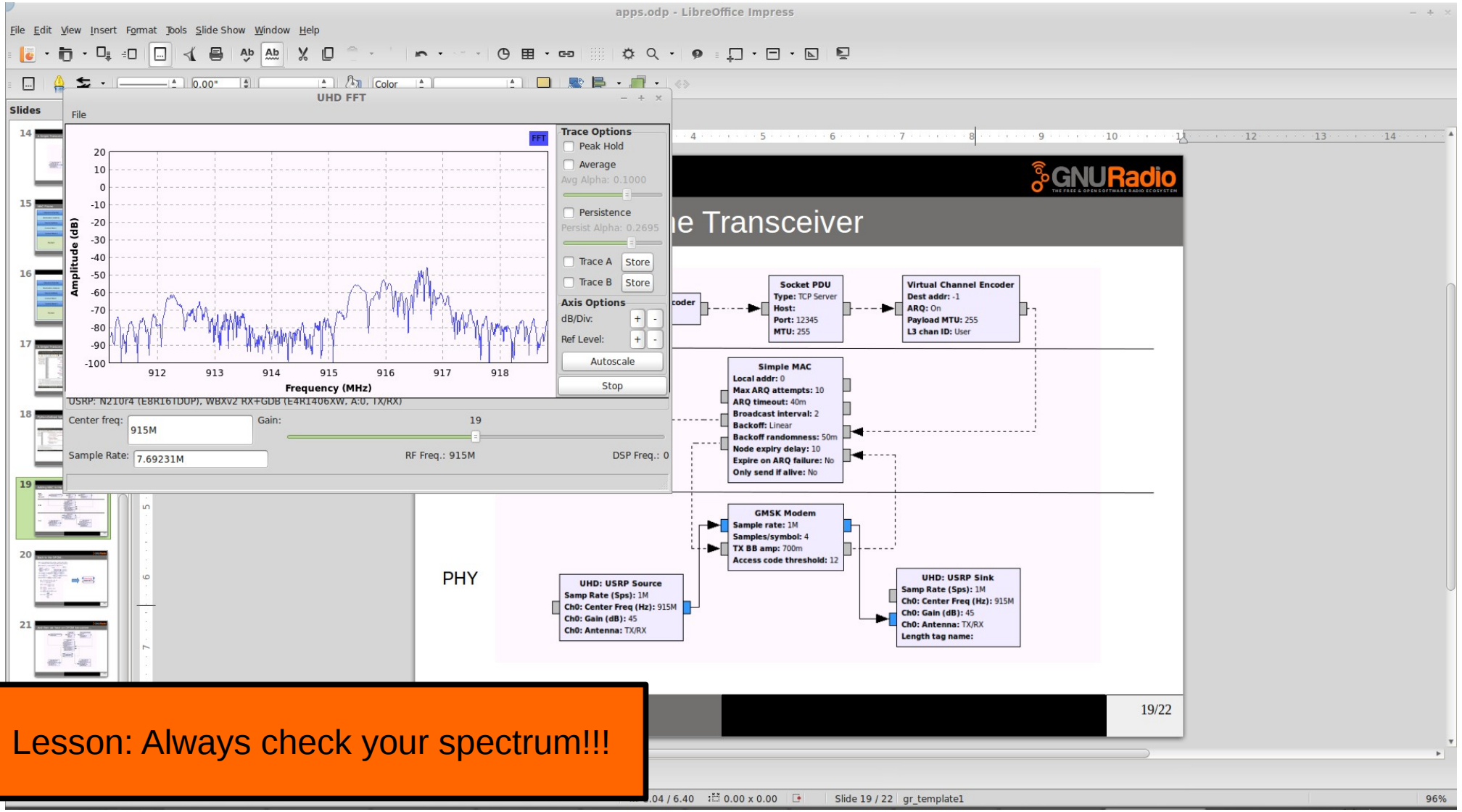
App/
Upper
Network

MAC

PHY

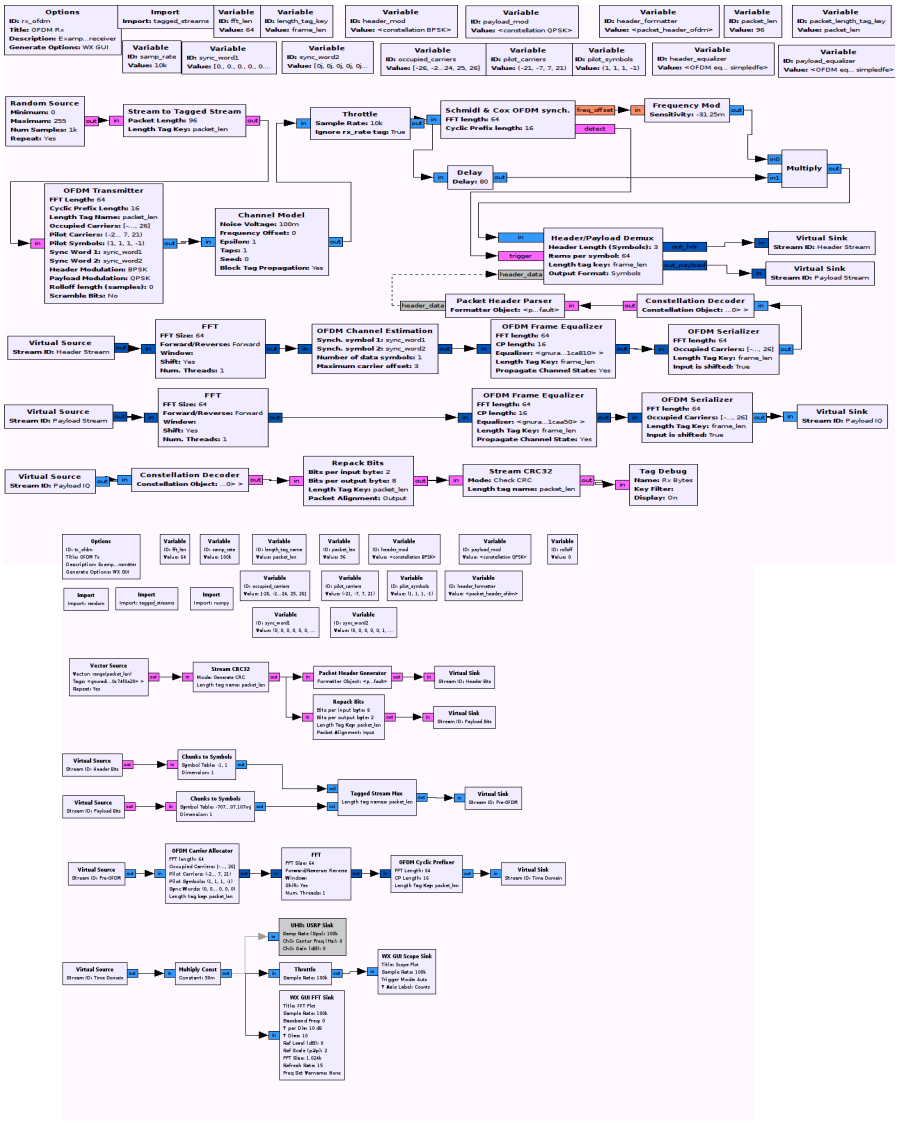


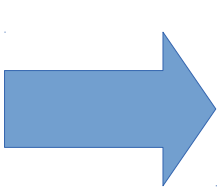
About 3.5 hrs later...

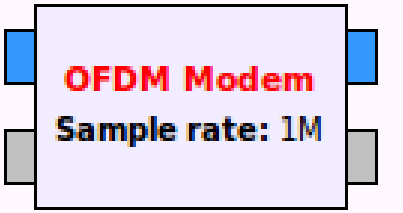


Lesson: Always check your spectrum!!!

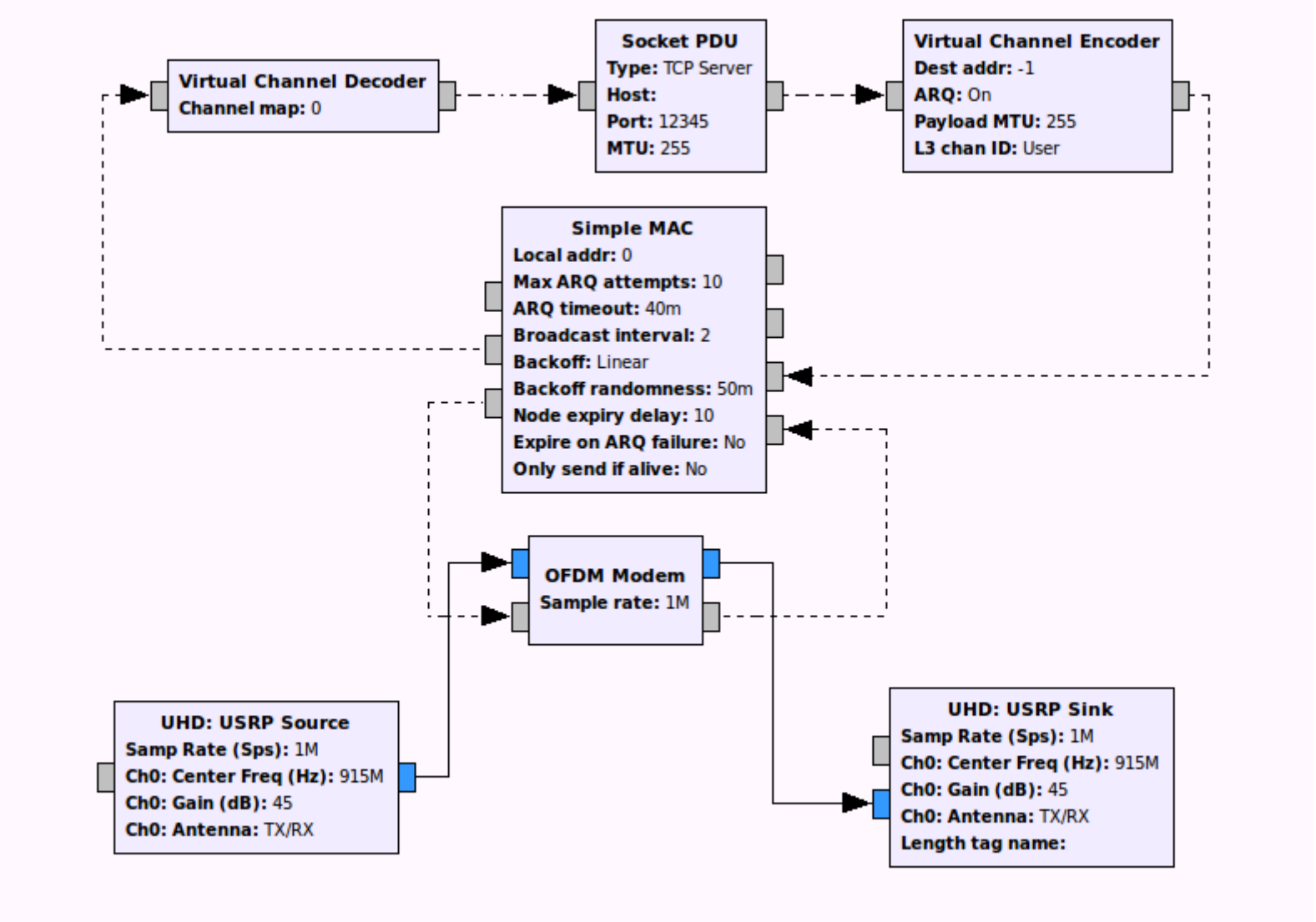
Back to the OFDM...







And then we have an OFDM transceiver...



Adding MAC to the Transceiver

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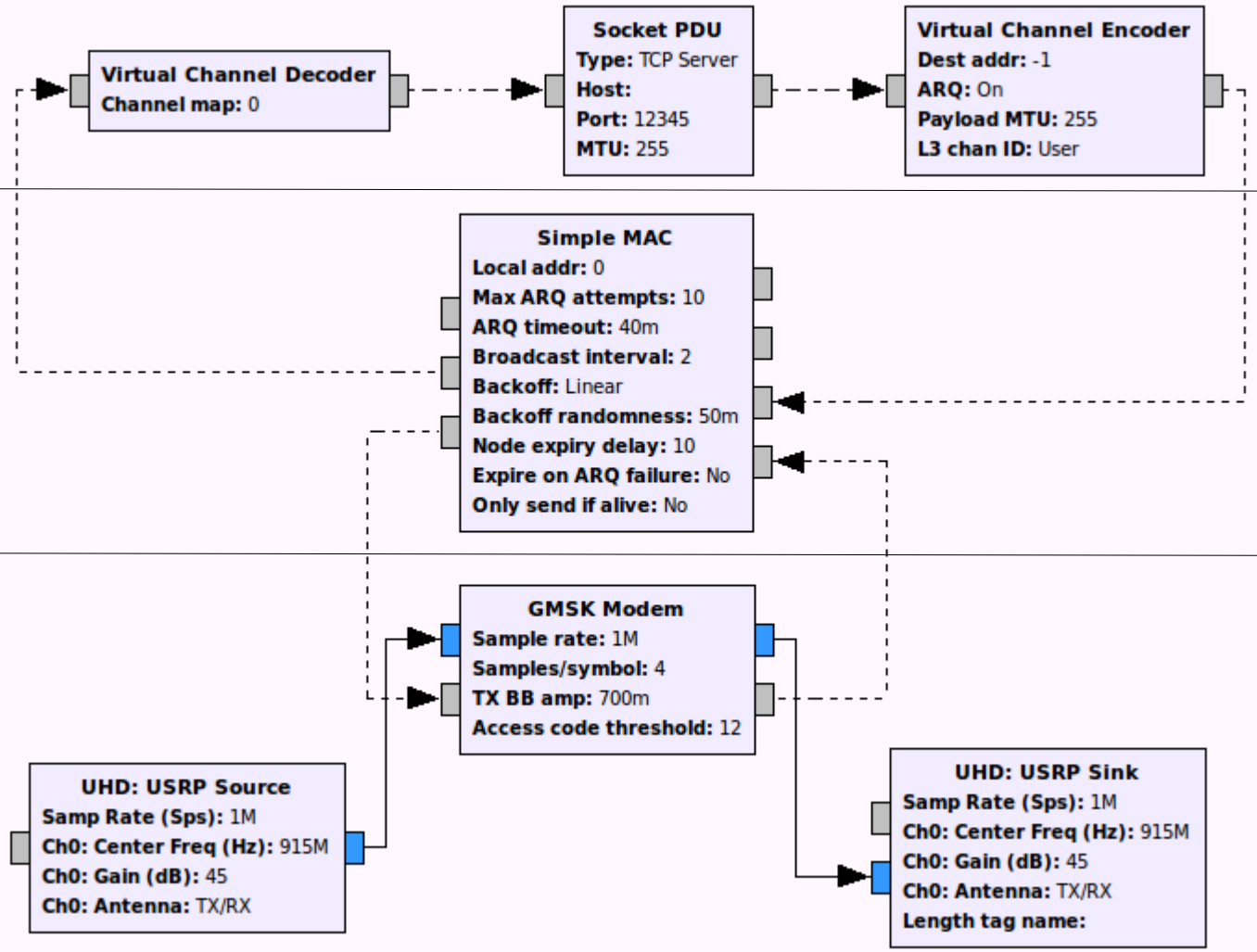
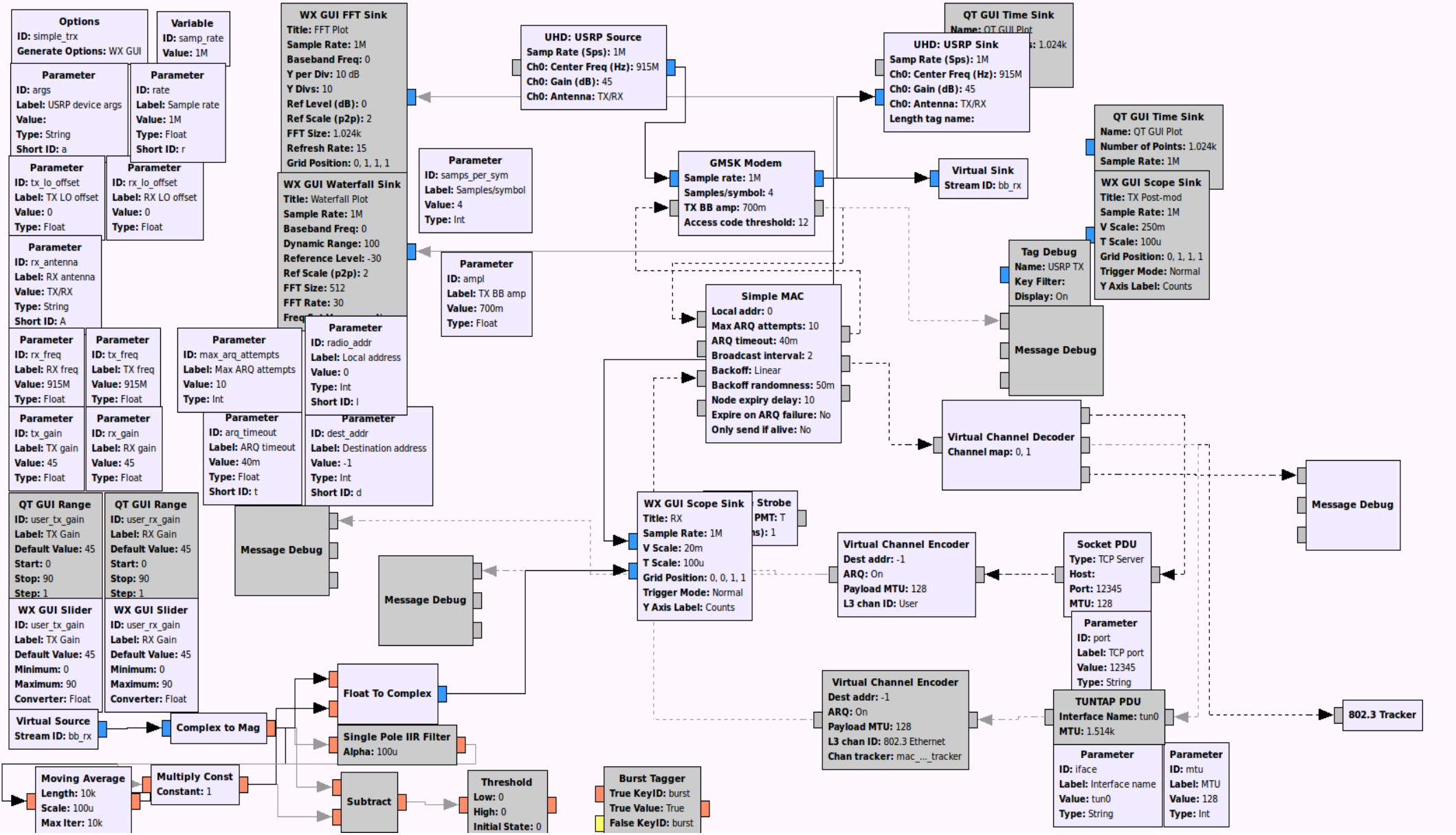
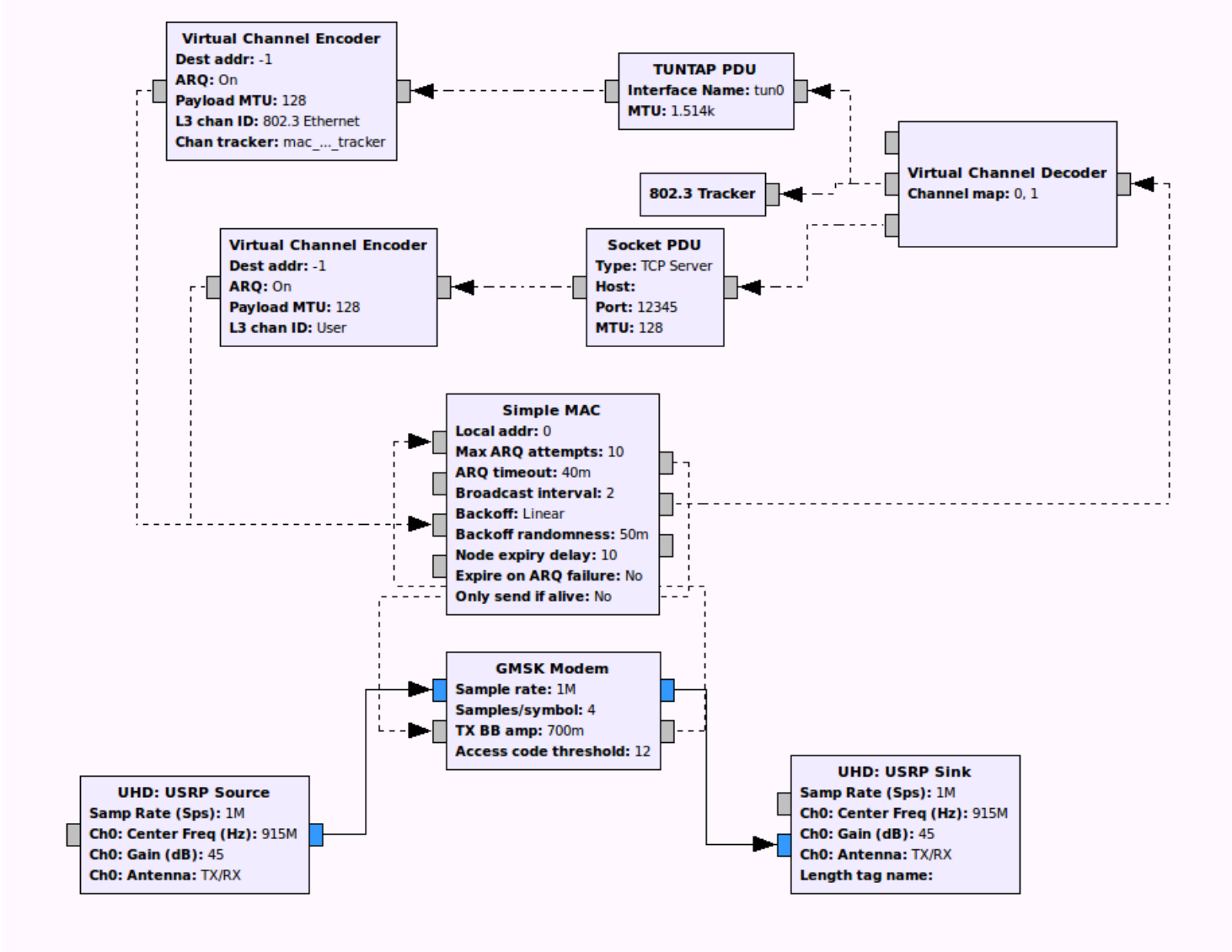


Balint added IP Networking!



But some of us (me) have OCD...

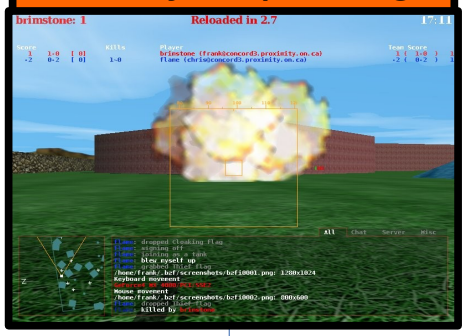


And then Balint kicked my butt in BZFlag...

IP Games over **gr-mac**

Balint's Tank
Mostly Shooting

My Tank
Mostly Exploding



gr-mac

gr-mac

USRP B200

USRP B200

Release the Rage in:

B200-BZFlag Demo

@ Hackfest on Friday!

Balint Winning (many times)

Other Ways to Interact with a Transceiver

```
#make the flowgraph
tb = simple_trx_mac(rx_antenna=antenna, rx_gain=options.rx_gain, tx_gain=options.tx_gain, a
tb.start()


while(1):
    if state == INIT:
        #start the FG - disable transmission until next state
        tb.set_ampl(0.0)
        if options.mode == "slave":
            print "I'm a slave, searching for channel."
            index = 0
            last_byte_count = 0
            period = 0.250
            tb.set_beacon_interval = 10.0
            state = SEARCH
        elif options.mode == "master":
            tb.set_beacon_interval = 0.1
            print "I'm a master, setting channel"
            state = MASTER_SET
        else:
            print "Invalid mode '%s' specified.  Exiting." % options.mode
```

```
    elif state == SEARCH:
        if not tb.simple_mac.get_rx_byte_count() > last_byte_count:

            try:
                freq = channels[index]
                print "Searching.  Setting Slave to %f MHz." % (freq/1e6)
                tb.set_rx_freq(freq)
                tb.set_tx_freq(freq)
                index = ( index + 1 ) % len(channels)
            except:
                print "Could not set SDR center frequency. Most likely a bad frequency index."
                sys.exit()

        else:
            print "Found downlink, moving to nominal comms state."
            state = NOMINAL
            tb.set_ampl(options.ampl)
            tb.set_tx_gain(options.tx_gain)
            period = 15.0
```

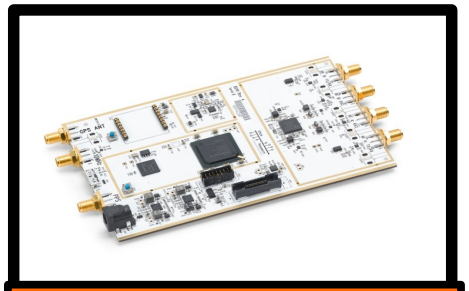
gr-mac Wishlist

PHY	Spread Spectrum		
Channel Access	RSSI-based Channel Sense Implementation	FHSS	TDMA
Networking Layer	QoS management	Self-organizing networks	Good Idea
FEC Integration	Anything from gr-fec	Good Idea	Good Idea
PHY/MODEM	Freq error correction and burst sync for GMSK Demod	Spread spectrum	QAM/PSK integration (test_corr_and_sync)
Utility	Traffic simulator	BSC Simulator	Shared channel simulator for bursty signals
ARQ	Sliding Window	Hybrid ARQ	Good Idea
Awesome-ness	FPGA PHY Integration (ie. RF NoC)	Embedded	Anything on Parallela
Boring but Important	Documentation	Throughput/ latency benchmarks	Python → C++

gr-mac Challenge

- You have an RTL-SDR!
- Low-power encoded beacon @ Hackerspace
- Hints:
  - GMSK modem
  - simple_trx.py might be a good place to start
  - Share results/progress with #grcon14 hashtag on twitter
  - Random parameters:
    - Multiple dazta rates < 125 kbps
    - Hopping across the amateur 33 cm band (KI4MTT)
  - Get help via Tutor Program!

Bounty:



USRP B200

Tours

```
john@yosemite ~/src/gr-mac/examples $ nc 127.0.0.1 12348
NOPE!S2KA6VT5KO7GP2BYEAYER1XKQ7ZH8YAFD59ZKGKC4F19KCDTL3CWBBHG1TQGEUGZTNV4ZWSFMC2ZAXA9
0LMB8YI2NYOGECUKNIL5UW9MZ9IOXY2XY01TX1G6LDBV0ZAM1PMPUKF1DMY4GGG9PVQ7LB6N45AUP2QY
NN2DGWUVBFYCRXJPHRRM87PSZO456DSBMHAWN33M50V877KD5ABE5EXU3YJV9JCHDONIHAB4N1EPO13X
GETTING WARMER!
68NPI8OPDUX1FTNEBMSKN8Q4PJ2IEV6SPDJ69PUDNC1A28OQ9BZN4AF7Q7HWCJZLQTBQ3PZ3E2OA1N4J
CQY6DFRYLKXXJ2Y9MJVO4ZTP7M6H532H07LV4CJVU1GLP36MZAFI498QQ60FF30DDNGLXHMHCGN04DDN
5WGDR4UC450DSLDS2RPVJB3R3AZHFI50T4JAATK6NU7JBD3TTTX3LOP7D7VLJSKV3PL6F1A8RHV0FVZT
FFRZQ9NZLOZ0LZ3JKDEO8F7RHADJ0OEH0WUQKIP3BNBVZJ5ILZTXXM4GFA80LDTW19HVZL787ABPV3J9
GRCON14!DK5DXGDRFOEG35QFN5GBDWY2IB6L9LMQEKHMJN59H0ZHGDEPI6SNBEAJP8PXIQ6MEO685IQ3KXJ88EFE
UN45SMZ3ORS3JEQCPJFH14BJDJ3D9XTC18N3AK06Z7HAILNF8H32ZB3NU4HDF6WK1DUPHTWYV5ZYDDCN
AXWT47MDHDDRN5HL4AVZ31SQSWZCN5G70FVE0UV3V9WBXS6HHHA3JCKNKCW9CB5154VFINEG0LRTWUVF
NOPE!6LZNLK48BH6HE2ZM89CD7MXGWGTP0QORB3VYHJYQC13YELNJMSO403UKROM6ZLXCI6P6AJU72NR0LYIA
TDX5EJJ23FZR5JVH4T4S9R3ZX5P2U1YS7BG2JPBNNETER3DF89UDK2DF9UVMI1QNV07Y5QMQ4WOO1KWP
9GUI42JZNCLINSET4FRL7I7AXP1BA30F7GWMPP7ARYTONGIOV6R3013XCQD9LLJM8DXXC1E7QN5V3PB4
LYYUYC21DQINI6YTSLSRHN820SVMEGN8X91NDIBAHJNDBYA9W11CKK5HFOL2G8PKSPUDDKKCIV0VQ4HB
```

http://github.com/jmalsbury/gr-mac