NPR (New Packet Radio)
A TCP/IP router for 70cm

David Ranch
KI6ZHD
BayCon 2020
2/9/2020

Who is this KI6ZHD guy anyway?

- BayNet's current Yaesu System Fusion and Black Mountain network lackee
- Silicon Valley AMPR coordinator (44.4.0.0/16)
- Interested in everything Linux & data. Active in:
  - Direwolf / Linpac / Fldigi, QSSTV. etc
  - 1200bps AX.25 packet (145.050) & APRS
  - First licensed in 2009

NPR: What is it?

- "NPR" stands for “New Packet Radio” yet it has nothing in common with the 1200bps AX.25 modes that you might be familiar with
- Protocol and modem designed by Guillaume F4HDK
  - NPR website: https://hackaday.io/project/164092
- This is a 70cm TCP/IP router-like device that can support transfer rates from 60Kbps up to 500Kbps of IPv4 traffic
- Uses a TDD (time division duplex) design similar to DMR radios with a theoretical distance of 300KM (186 miles)
- Supports either simplex or hybrid full duplex configurations either for point to point or point to multi-point configurations

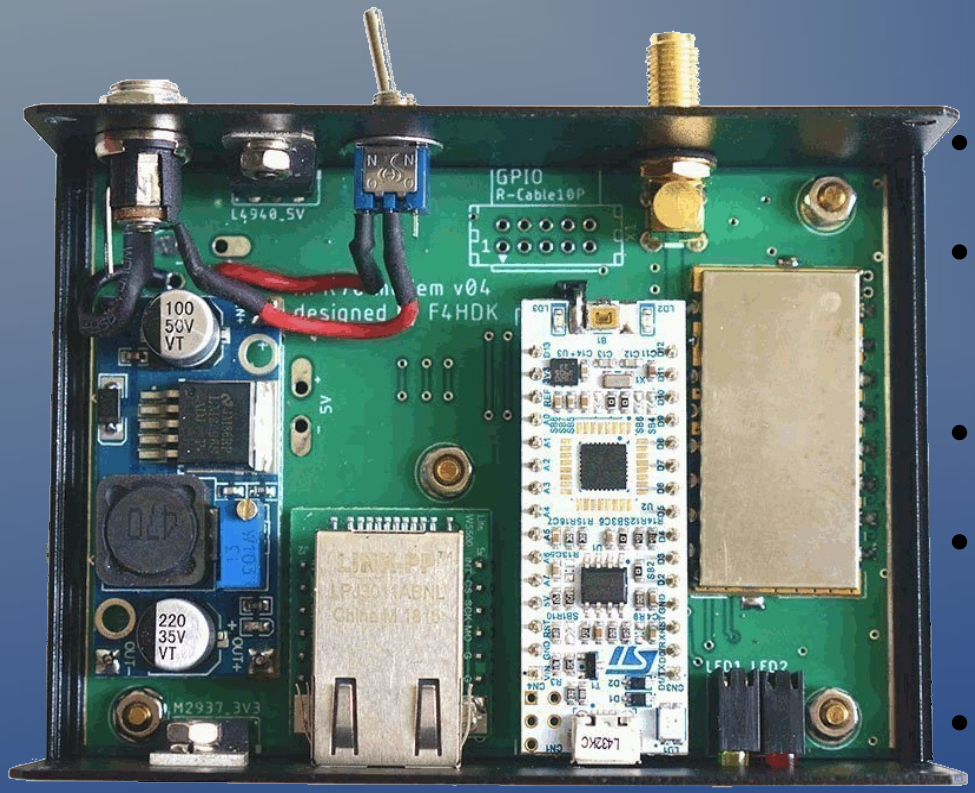
NPR: Why is it needed?

- 70cm RF propagation offers more connectivity options than what 2.4, 3.4, or 5.8Ghz can
- Complementary to high speed systems for long distance or difficult to reach destinations
- Not every situation needs multi-megabit speeds
- Whole new protocol to play with that is tailored to meet amateur radio requirements (Part 97: no encryption, IDing, etc)
- The client setup is simple and the master pushes future configuration changes to all clients
- Inexpensive: $79 US for a fully built NPR modem
- Possible Use-cases:
  - Provide IP connectivity when other solutions won't work
  - Admin network access when the Internet is down

What will BayNet users be able to do?

- For now, get Internet access via Baynet's 44.4.128.0/22 AMPR subnet while mobile, maybe a backup connection, etc
- Run AREDN/BBHN applications like MeshChat, MatterMost, XMPP/Jabber, IRC, VoIP,
  - https://arednmesh.readthedocs.io/en/latest/arednServicesGuide/services_overview.html
- Future use cases such as DTV, VoIP, etc. Sky is the limit!
- Other possible options can always be considered

NPR: What's inside?



- The heart is a Silicon Labs SI-4463 (30 dbm / 1 watt) transceiver and a Nucleo STM32 L432K SBC
- Open source PCB and software
- Users can build their own modems or buy a pre-built unit
- Flexible input power options
- STM32 SPI bus declocked from 80Mhz to 20MHz to minimize RFI
- Beyond NPR: The Si-4463 transceiver supports other modes like 2FSK, 4FSK, GMSK, OOK so with your own firmware, this can be a reference board to play with entirely different ideas

NPR: 5 Different Modulations

- Different modulations to suit different rules
- Modulation types are selectable between 2GFSK or 4GFSK with FEC
- To meet current US FCC regulations, our highest speed transmission mode is 100Khz wide and 50Ksymbol/sec yielding ~60Kbps of IP payload (real world)

- Meaning of 2 digits
  - 1ier digit: 2GFSK or 4GFSK
  - 2ième digit: Symbol Rate

	Modulation name 2nd digit	**x0**	**x1**	**x2**	**x3**	**x4**	
	Symbol Rate	50	100	180	300	500	kS/s
	Radio bandwidth	100	200	360	600	1000	kHz
2GFSK (1st digit of name : 1x)	**Modulation name**		**11** (*)	**12** (*)	**13**	**14**	
	Raw data rate		100	180	300	500	kbps
	Usable data rate		71	120	190	300	kbps
4GFSK (1st digit of name : 2x)	**Modulation name**	**20** (*)	**21** (*)	**22**	**23**	**24**	
	Raw data rate	100	200	360	600	1000	kbps
	Usable data rate	68	130	220	330	470	kbps

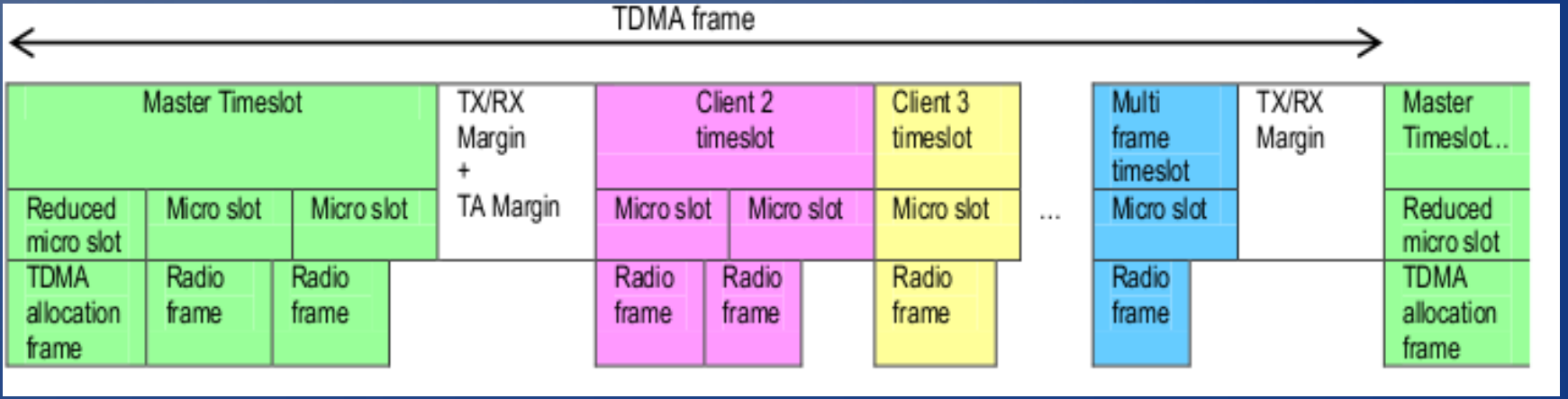
NPR: It's RF behavior

- NPR is a managed timeslot protocol so no collisions are possible (think Token Ring)
- Three general modes for a single connected client to master setup:
  - Disconnected : master sends a “presence” poll packet every 15 seconds
  - Connected / slow : client sends out a poll packet every 4.5 seconds (560ms slot per client) to maintain connected state
  - Connected / active fast- bi-directional packets sent every 560ms (depends on modulation to transfer low data rates
    - ICMP “ping” latency can range from 350 to 550ms
  - Connected / active fast #2 – longer bi-directional packets sent allocated with more timeslots depending on the pending traffic
- The TDM slot allocation is calculated by the master in real time depending on the data queue length

NPR: TDM timing

- NPR's timing is broken down into 17 “micro-slots” where the slots are distributed across all client modems depending on slow / fast clients
  - These are then grouped into “4x” or “8x multi-frames”

- Fast TX/RX timing cycles from 80ms to 200ms (depending on modulation)
- Max “Timing Advance” is 2ms to support a RTT of 300KM



NPR and a companion DMR amplifier

- Paired together, the amplifier will get you to about 20 Watts TX

NPR: Compared to analog POTS modems

- This ~60Kbps TCP/IP rate is NOT like an old school dial-up modem running at ~56Kbps (just ASCII payload)
- 56Kbps analog modems only supported point to point connections vs NPR is a point to multi-point solution
- To connect to the Internet via an analog modem, users were actually using TCP/IP over PPP over analog modem which is a lot slower
  - Both analog 56Kbps connections (53Kbps actually) and NPR connections offer asymmetrical speeds
  - Analog modems offer v.42bis compression where as NPR doesn't compress IP payloads today
- Latency is variable depending on the NPR modem's mode. NPR end to end latency is variable 350ms to 650ms

NPR: Compared to D-Star-DD (128Kbps)

- Dstar-DD is a 128Kbps RAW protocol that operates on a Layer-2 (Ethernet frame) level and yields a ~90Kbps usable TCP/IP payload
- Limited client hardware: Only the EOL'ed Icom ID-1 mobile or new Icom IC-9700 VHF/UHF base-station radio offer Dstar-DD 1.2Ghz
- Operation on 1.2Ghz can have challenging RF propagation issues
- The Dstar-DD radio acts as a Layer-2 bridge to the repeater side
- Addressing is controlled via your Callsign's Dstar registration
- Dstar-DD configuration builds on top of the standard D-star configuration parameters but effectively this all requires IP subnet coordination usually via a static DHCP server

NPR: It's “router like”

- What do I mean by being a "router-like" (compared to say a Wifi AP) access point
- Every IP address in the DHCP scope is proxy-arp'ed by the Master NPR node regardless if there are active clients or not
- The master and clients are on the same subnet; it doesn't route, NAT, or otherwise manipulate packets
- IPv4 Unicast traffic only / no broadcast or multicast support today
- Max MTU is 1500 bytes but 750 bytes is optimal to align to the TDM micro-slot design
- 100BaseT hardware is hardcoded in firmware to run at 10BaseT to avoid common HF interference common with 100Mbps links

NPR's CLI (via serial or TELNET)

```
ready> display config
CONFIG:
  callsign: 'KI6ZHD-M1'
  is_master: yes
  MAC: 4E:46:50:52:F6:2F
  frequency: 437.000MHz
  freq_shift: 0.000MHz
  RF_power: 25
  modulation: 20
  radio_netw_ID: xx
  radio_on_at_start: yes
  telnet active: yes
  telnet routed: yes
  modem_IP: 192.168.0.253
  netmask: 255.255.255.0
  master_FDD: no
  IP_begin: 192.168.0.65
  master_IP_size: 32 (Last IP: 192.168.0.96)
  def_route_active: yes
  def_route_val: 192.168.0.254
  DNS_active: yes
  DNS_value: 192.168.0.1
ready>
```

```
ready> status
   1 status: connected TA:0.0km Temp:29degC
   RX_Eth_IPv4 330509 ;TX_radio_IPv4 210598 ;
RX_radio_IPv4 72074
   DOWNLINK - bandwidth:0.5 RSSI:-67.4 ERR:0.00%
   UPLINK -   bandwidth:1.4 RSSI:-68.0 ERR:0.00%
CTRL+c to exit...
```

```
ready> who
3 Master: ID:127 Callsign:KI6ZHD-M1
ME: Callsign:KI6ZHD-2 ID:0 modem IP:192.168.0.253
Clients:
 ID:0 Callsign:KI6ZHD-2 IP start:192.168.0.65 IP end:192.168.0.65
ready>
```

NPR: iperf performance for one client

- Some buffering is present so numbers can fluctuate

- Master to Client #1 (TCP)

  0.0-94.0 sec 640 KBytes 55.8 Kbits/sec

- Client #1 to Master (TCP)

  0.0-84.0 sec 512 KBytes 49.9 Kbits/sec

NPR: It's current state today..

- Not intended to be a LAN to LAN connectivity solution
- Maximum of 7 remote endpoints
- If a client is connected to the master, the link will never be torn down even if the client is idle. This currently locks out other clients OUT of the network
- The full duplex design is only master-centric today. Clients support is half duplex
- SI-4463 receiver is known to be limited, has a wide-open RX passband. It needs a preamp, and ideally a tuned duplexer
- The RF4463 board's USB port is susceptible to RFI
- FEC is overly simple : users must try to keep the Bit Error Rate (BERR < 2%)
- Recommended DMR amp selection is limited and built-in pre-amp requires amp to be active at all times (no RX only mode)
- Serial or TELNET CLI is simple and troubleshooting features are very limited today
- Static IP support is limited
- A 2m version is technically available but only for DIY builds and is a WIP

NPR: Evolution in the future

- Near Future enhancements
  - FDD improvements for simultaneous transmit and receive support at the master
- Later enhancements under consideration
  - Support up to 15 end clients
  - NPR protocol to move down the OSI stack to transmit Ethernet frames (not IPv4 frames). This will allow for IPv6 packets but also increase overhead. This is how Dstar-DD works today
  - Possible MSS clamping to align to optimal 750byte MTU which aligns to NPR's TDM timing
  - Maybe the US FCC will drop the current symbols/second restriction but this has been pending since 2013

How do interested BayNet users get started?

- Get KI6ZHD to get off his butt and deploy the master node up on the Baynet repeater site
- Reach out to KI6ZHD to get the NPR configuration details
- Users (you):
  - Build up or buy an NPR modem
  - Buy a qualified DMR amp
  - Buy or build a high gain directional 70cm antenna

    One good option is the M2 Antennas 440-6SS
  - Buy needed coax, connectors, power supplies, etc
  - Assemble your system
  - Follow the NPR Advanced guide to get things online

References

- Some pictures and diagrams in this presentation are from F4HDK or Funtronics's documentation
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- IEEE article
  - https://spectrum.ieee.org/geek-life/hands-on/build-a-longdistance-data-network-using-ham-radio
- Youtube video from F4HDK
  - https://www.youtube.com/watch?v=eyCTPeAjbTo
- Funtronics NPR modems (pre-built and kits)
  - https://elekitsorparts.com/product/npr-70-modem-by-f4hdk-new-packet-radio-over-70cm-band-amateur-radio-packet-radio

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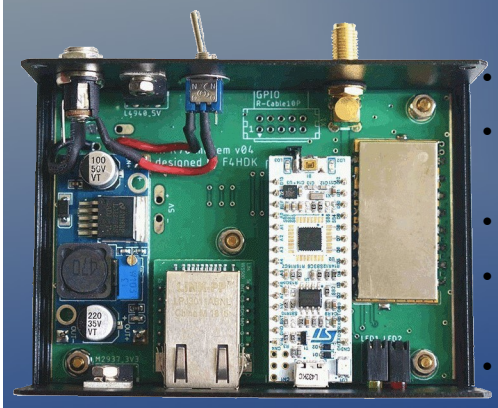

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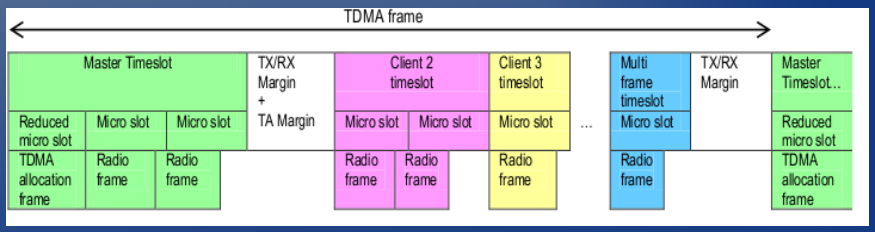

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