Repeater Linking

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Topics

- History and Terminology

- Linking Analog Repeaters

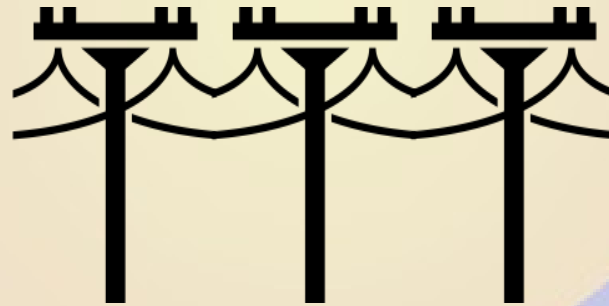- Linking Digital Repeaters

- Linking Different Modes

Co-located Linked Repeaters

- Audio from repeaters are mixed in the repeater controller

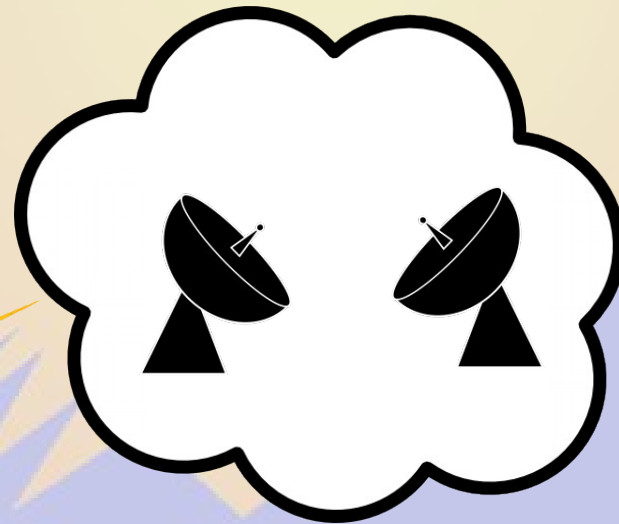- Everything else is just this on steroids

Analog Linked Sites

- Analog audio is passed between sites

Digital Linked Sites

- Digital traffic is passed between sites
- Needs a device to convert analog/digital

Advantages of Digital Linking

- Redundant network routing

- Better Control
  - Links can be dropped

- Better monitoring
  - Trace the source of noise

- Flexibility
  - Remote control of links
  - Rerouting links

Link Types

- Analog
  - Line level audio

- Digital Audio
  - VOIP
  - Echolink
  - IRLP
  - AllStarLink

- Native Digital
  - IP Site Connect (MotoTrbo™)
  - Brandmeister
  - P25 HDLC (V.24)
  - MMDVM

Converting Signals

- Codec (encode & decode)
  - analog to digital and digital to analog

- Vocoder
  - Codec optimized for voice

- Transcoding
  - Conversion between digital audio formats
  - Native digital to digital audio to native digital

Digital Audio Formats

- PCM (Pulse-code Modulation)
  - A-law
  - μ-law
  - GSM (EFR,AMR)
  - ADPCM (Adaptive Differential PCM)
- Bandwidth = fidelity
  - GSM   36kbps OK
  - ADPCM 55kbps Good
  - μ-law   87kbps Best

AMBE

- Advanced Multiband Excitation
  - Most popular radio vocoder
- IMBE (older iteration of AMBE)
  - P25 Phase 1
- AMBE
  - D-STAR
- AMBE+2
  - P25 Phase 2
  - DMR
  - NXDN
  - Fusion
- Requires a license or buying their chip

Linking Topology

- Reflector
    - Repeaters Connect to a Reflector
    - IRLP, Brandmeister, c-Bridge

- Ad Hoc
    - Any repeater can connect to any repeater
    - Daisy chain, star, hub, ...
    - AllStarLink

- Gateway
    - Link disparate technologies

Advanced Linking

- Cross linking
  - Both repeaters transmit from both receivers
- Mixing
  - Transmit all received signals
- Voting
  - Transmit only the strongest received signal
- Simulcast
  - Multiple transmitters on same frequency

History of Radio over IP

- 1996   Repeater Link (Mark Brown N9YMQ)

- 1997   IRLP (Dave Cameron VE7LTD)

- 2002   WIRES (Yaesu)

- 2002   Echolink (Jonathan Taylor K1RFD)

- 2002   AllStarLink (Jim Dixon WB6NIL)

- 2007   TheLinkBox (Sumner Hansen WB6YMH)

Advantages of AllStarLink

- Most configurable
  - Any node can connect to any other node
  - Configurable port allows multiple nodes per IP
  - Codec selectable for each link
  - Multiple repeaters per server
  - Private nodes/networks

- Most capable
  - CD quality audio
  - Supports mixing, voting and simulcast
  - Control and monitor with AllMon

- No network configuration for outbound connections

What is AllStarLink?

- Repeater linking with Asterisk PBX
  - Asterisk is a VOIP Phone Exchange
  - apt_rpt is the module supporting repeaters

- Repeater interface
  - USB audio interface CM-1xx family
    - DMK URI (USB Radio Interface)
    - RB RIM (Repeater Interface Module)
  - Radio Thin Client Module (RTCM)
    - IP connected
    - GPS timing for voting/simulcast

AllStarLink Repeaters North America

Public ASL Repeaters Colorado
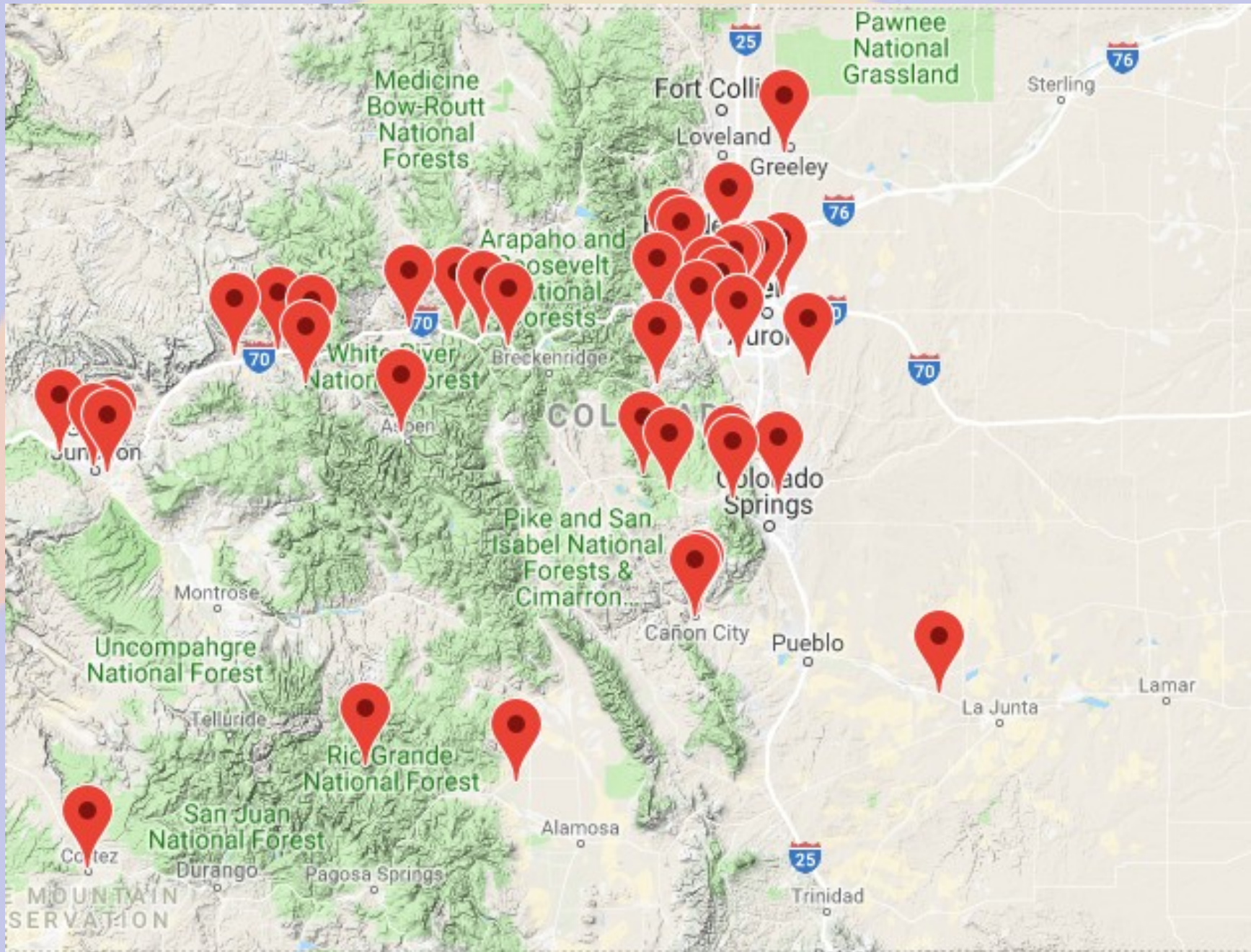
DMK URI

- Original USB Radio Interface from DMK

- DB25 radio interface

  - Stereo audio in

  - Stereo audio out
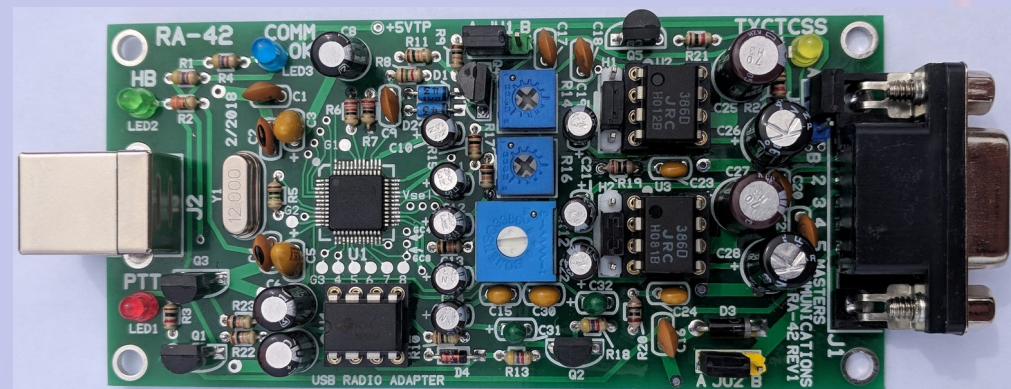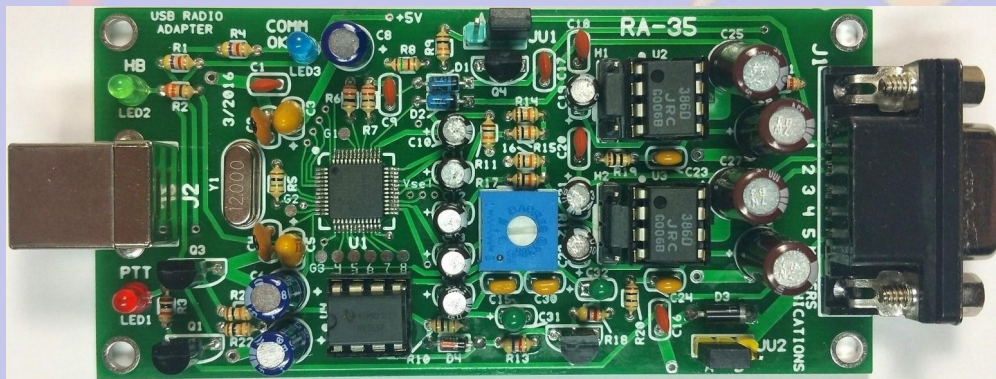
  - PTT

  - COR+CTCSS in

  - GPIO

- $85 for hams

Repeater Builder RIM

- Feature Rich
    - Low pass filter
    - Fail safes
    - Status LEDs
    - $100

- Rim Lite
    - Port compatible with
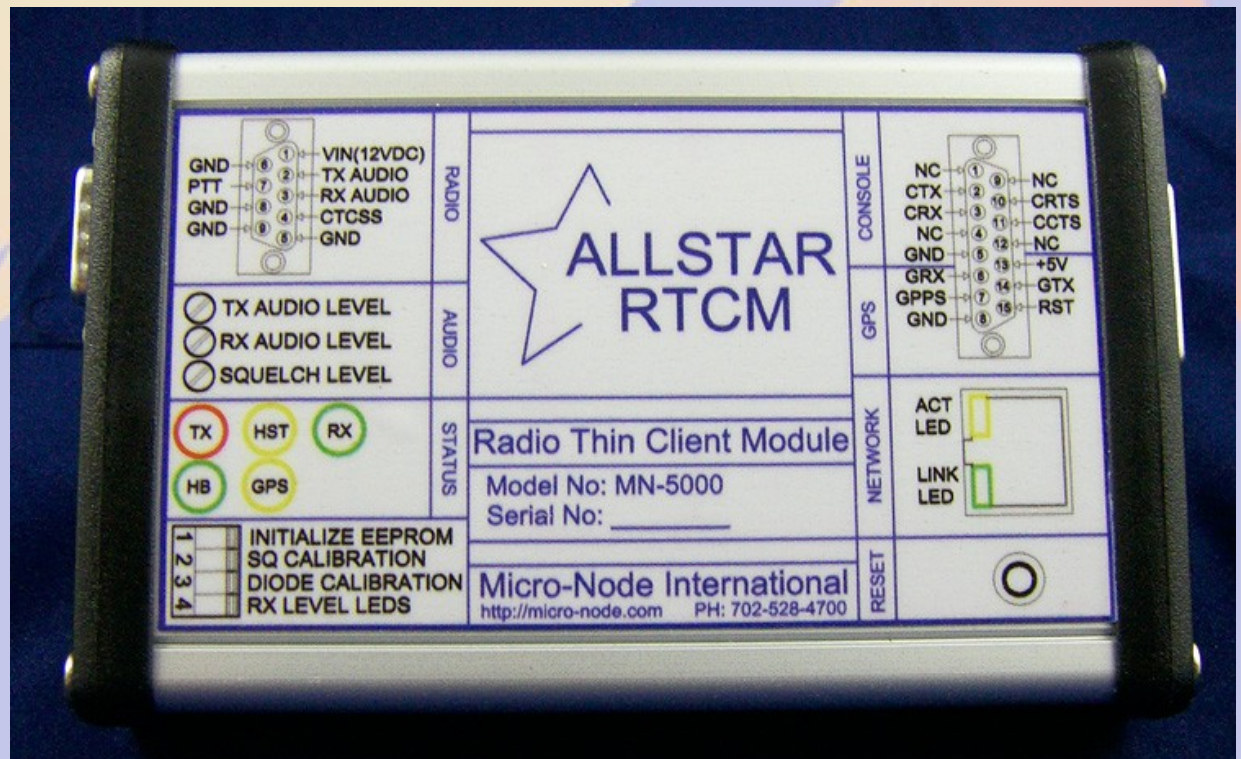   - SCOM 7330
        - MaxTrac
    - $50

Masters Communications

- Low cost kit or assembled
  - RA-35 USB ($35 kit, $60 built)
  - RA-40 USB+TX level control ($40 kit, $65 built)
  - RA-42 USB+TX CTCSS GPIO ($42 kit $67 built)

Radio Thin Client Module

- Can function as a simple repeater controller

- Normally used as a TCP/IP interface to radio

- Required for voting

- $269

- Used on Colorado Connection Repeaters

- Watch reset!

AllStarLink Distributions

- Obsolete Distributions
  - ACID
    - CentOS 5
  - Limey

- Current Distributions
  - DIAL
    - Debian/x86
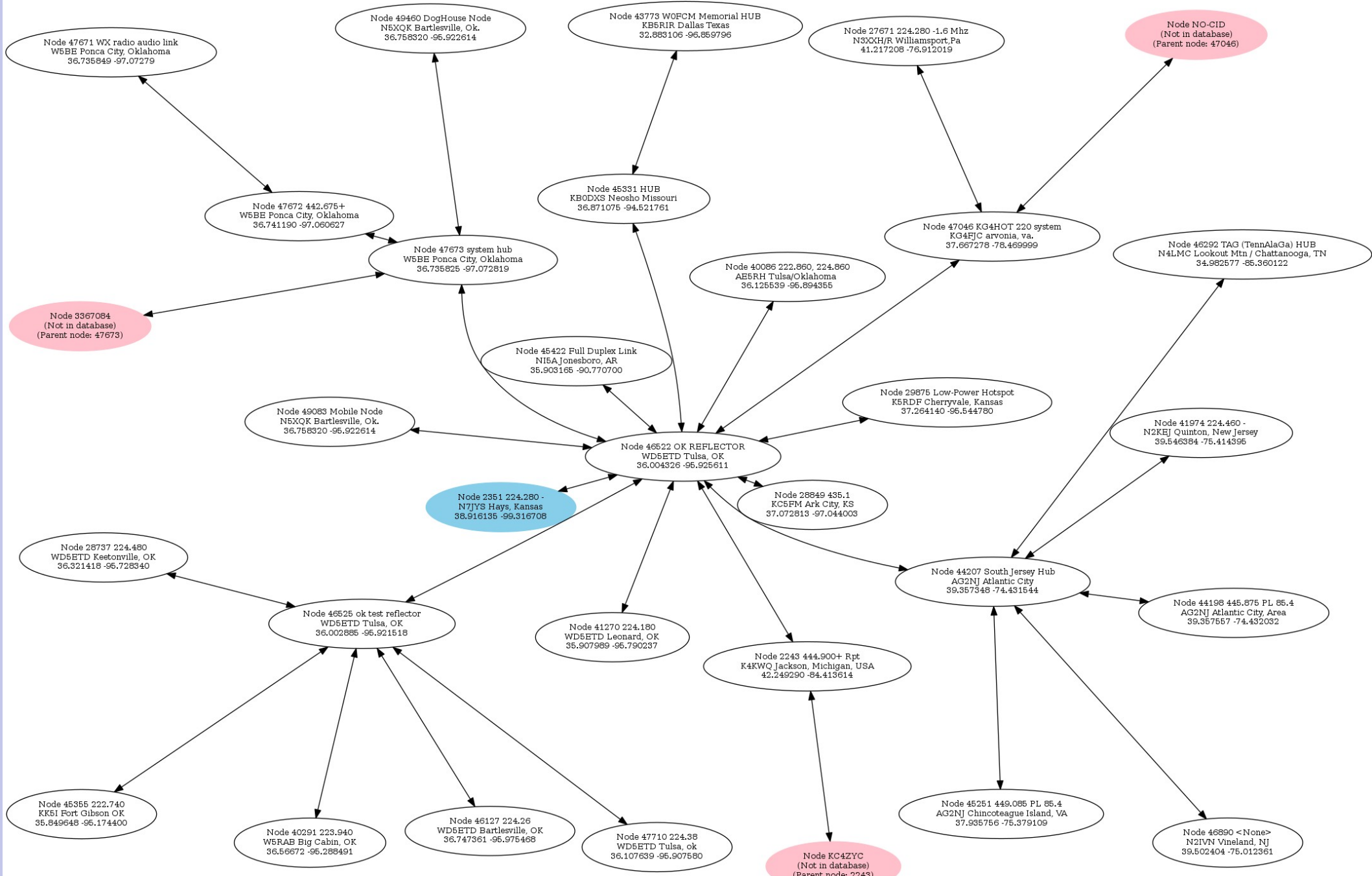   - Raspian/ARM
  - HamVOIP
    - Arch/ARM

AllStarLink Terminology

- Server
  - Asterisk instance
    - Sometimes mistakenly called a node
  - One per computer

- Node
  - Collection of devices forming a repeater
    - One USB connected repeater
    - One or more RTCMs mixing
    - Multiple RTCMs voting
  - One or more nodes per server

- Hub
  - Radioless node

Node Numbering

- 1000-1999
  - Private node
  - You must maintain node to IP:port mapping
- 2000-2600, 20000-29999,40000-49000
  - Public node
  - IP:port mapping managed by AllStarLink
- Connections are made between nodes
- Public and private nodes can connect

Linked System

Node 47671 WX radio audio link
W5BE Ponca City, Oklahoma
36.735849 -97.07279

Node 49460 DogHouse Node
N5XQK Bartlesville, Ok.
36.758320 -95.922614

Node 43773 W0FCM Memorial HUB
KB5RIR Dallas Texas
32.883106 -96.859796

Node 27671 224.280 -1.6 Mhz
N3XXH/R Williamsport,Pa
41.217208 -76.912019

Node NO-CID
(Not in database)
(Parent node: 47046)

Node 47672 442.675+
W5BE Ponca City, Oklahoma
36.741190 -97.060627

Node 45331 HUB
KB0DXS Neosho Missouri
36.871075 -94.521761

Node 47673 system hub
W5BE Ponca City, Oklahoma
36.735825 -97.072819

Node 47046 KG4HOT 220 system
KG4FJC arvonia, va.
37.667278 -78.469999

Node 46292 TAG (TennAlaGa) HUB
N4LMC Lookout Mtn / Chattanooga, TN
34.982577 -85.360122

Node 40086 222.860, 224.860
AE5RH Tulsa/Oklahoma
36.125539 -95.894355

Node 3367084
(Not in database)
(Parent node: 47673)

Node 45422 Full Duplex Link
N5AJonesboro, AR
35.903165 -90.770700

Node 29875 Low-Power Hotspot
K5RDF Cherryvale, Kansas
37.264140 -95.544780

Node 41974 224.460 -
N2KEJ Quinton, New Jersey
39.546384 -75.414395

Node 49083 Mobile Node
N5XQK Bartlesville, Ok.
36.758320 -95.922614

Node 46522 OK REFLECTOR
WD5ETD Tulsa, OK
36.004326 -95.925611

Node 28849 435.1
KC5FM Ark City, KS
37.072813 -97.044003

Node 2351 224.280 -
N7JYS Hays, Kansas
38.916135 -99.316708

Node 44207 South Jersey Hub
AG2NJ Atlantic City
39.357348 -74.431544

Node 28737 224.480
WD5ETD Keetonville, OK
36.321418 -95.728340

Node 44198 445.875 PL 85.4
AG2NJ Atlantic City, Area
39.357557 -74.432032

Node 46525 ok test reflector
WD5ETD Tulsa, OK
36.002885 -95.921518

Node 41270 224.180
WD5ETD Leonard, OK
35.907989 -95.790237

Node 2243 444.900+ Rpt
K4KWQ Jackson, Michigan, USA
42.249290 -84.413614

Node 45355 222.740
KK5I Fort Gibson OK
35.849648 -95.174400

Node 40291 223.940
W5RAB Big Cabin, OK
36.56672 -95.288491

Node 46127 224.26
WD5ETD Bartlesville, OK
36.747361 -95.975468

Node 47710 224.38
WD5ETD Tulsa, ok
36.107639 -95.907580

Node 45251 449.085 PL 85.4
AG2NJ Chincoteague Island, VA
37.935756 -75.379109

Node 46890 <None>
N2IVN Vineland, NJ
39.502404 -75.012361

Node KC4ZYC
(Not in database)
(Parent node: 2243)

Allstar Link [surrounding node 2351] status of 04/13/19 02:49:59 GMT

Linked Private Repeaters

- View from AllMon

- Node 1001 has no radio so it is called a hub

Node	Node Information	Received	Link	Direction	Connected	Mode
1956	1956 Durango 147.345+ 88.5/123.0 Missionary	000:00:05	ESTABLISHED	OUT	144:47:13	Transceive
1930	1930 Denver 145.310- 88.5/123.0 Thorodin Voter	000:06:45	ESTABLISHED	IN	328:52:41	Transceive
1954	1954 Colo Spgs 145.310- 88.5/123.0 Chey Mtn	000:14:14	ESTABLISHED	IN	25:19:25	Transceive
1933	1933 Leadville 145.445- 88.5/123.0 Mosquito	000:28:26	ESTABLISHED	OUT	144:47:13	Transceive
1960	1960 Akron 145.400- 88.5/123.0 Akron, Co rPi	000:52:31	ESTABLISHED	OUT	48:22:22	Transceive
1931	1931 Vail 147.345- 88.5/123.0 Upper Dowd	001:20:43	ESTABLISHED	OUT	144:47:13	Transceive
1932	1932 Vail-Eagle Link Upper Dowd	001:55:22	ESTABLISHED	OUT	144:47:13	Transceive
1929	1929 FTC 146.730- 88.5/123.0 Rattlesnake	054:51:45	ESTABLISHED	OUT	144:47:13	Transceive
1927	1927 Breck 147.390+ 88.5/123.0 Baldy	056:05:51	ESTABLISHED	OUT	144:47:13	Transceive
1926	1926 Winter Park 147.285+ 88.5/123.0	076:59:25	ESTABLISHED	OUT	144:47:13	Transceive
1953	1953 Salida 147.285+ 88.5/123.0 Methodist	Never	ESTABLISHED	IN	25:19:25	Transceive

Node **1001** - 1001 Connection Hub Thorodin Mtn Golden, CO *Bubble Chart*

Voting Repeater

- View from AllMon
- Green is the selected voter
- Blue is a non-selected voter
- One transmitter (Thorodin_A)
- Master timing source is Squaw

Node 1930 - 1930 Denver 145.310- 88.5/123.0 Thorodin Voter	
Client	**RSSI**
Thorodin_A	0
Squaw Master ActiveMaster	213
LeeHill	252
K2AD	0
KI0KN	0

Configurating a Public node

- Create account on Portal

  - www.allstarlink.org

- Under Portal > Server Settings

  - Add a new server

- Under Portal > Node Settings

  - Request a new node number

  - Node number request is associated with a server

- This is not required for private nodes

Server List

Server Settings

Node List

- Password is shown when mouse is over password fields

Node Settings

Installing AllStarlink

- ## Complete images

  - https://github.com/AllStarLink/Asterisk/releases/download/ASL-1.01/ASL_1.01-20180417-amd64-i386-debian-stretch-netinst.iso

  - http://dvswitch.org/files/ASL_Images/Raspberry_Pi/Stretch/ASL_1.01-20180228-armhf-raspbian-stretch-image.img

- ## Prevent kernel updates (rPi)

  - sudo apt-mark hold raspberrypi-kernel-headers raspberrypi-kernel

- ## Install from repository

  - wget http://dvswitch.org/install-allstarlink-repository

  - chmod +x install-allstarlink-repository

  - ./install-allstarlink-repository

  - apt-get update

  - apt-get install allstarlink

Where stuff are
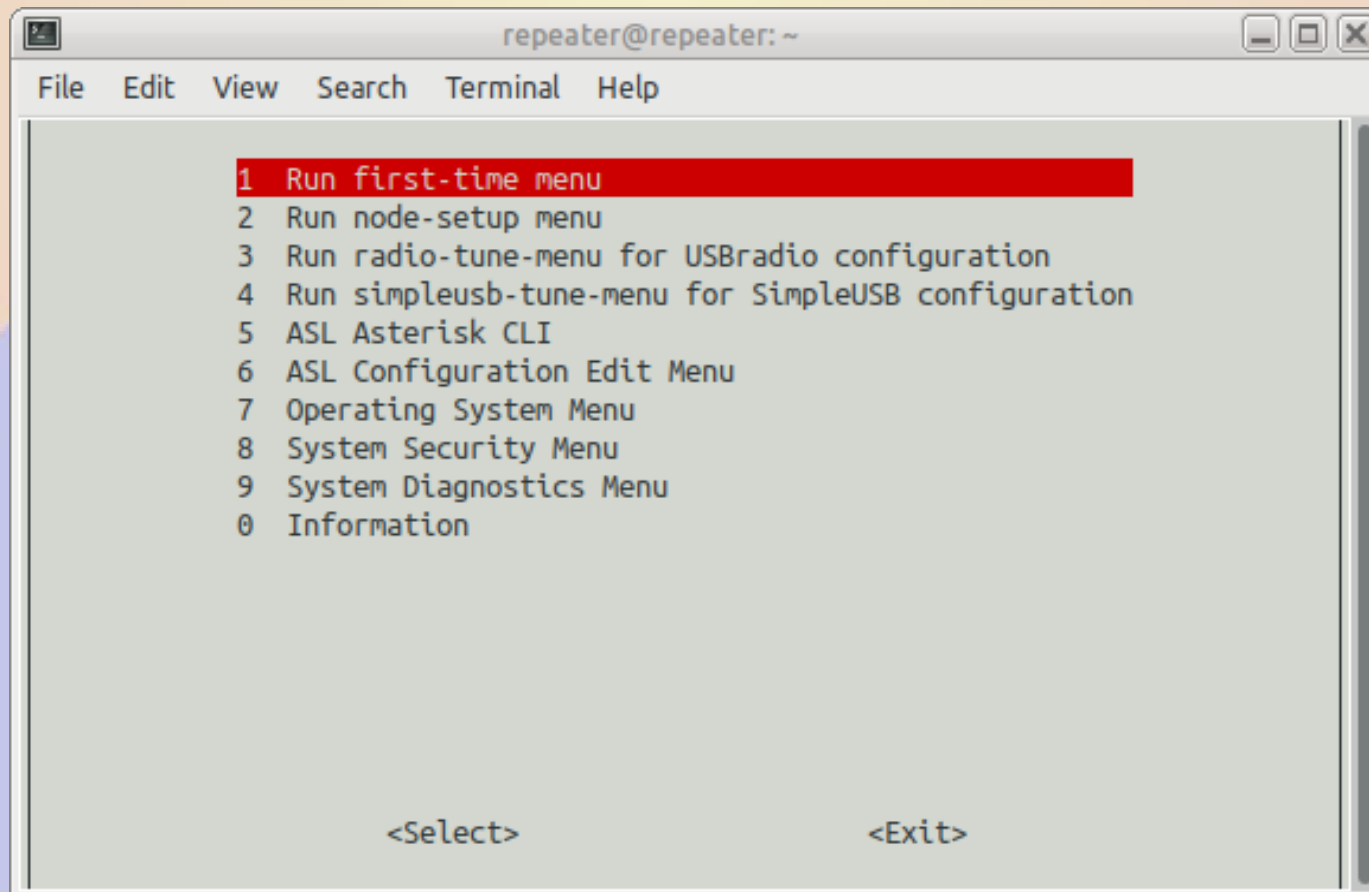
- /etc/asterisk

  - Configuration files

- /usr/local/sbin

  - asl-menu, astdn.sh, astres.sh and other scripts

- /var/log/asterisk

  - messages and other logs

- /var/lib/asterisk

  - rpt_extnodes (list of public nodes)

  - sounds (provided and custom sound files)

Initial Login and Configuration

- IP is obtained from DHCP

  - Host name is *repeater*

- Log in to the server

  - ssh repeater@X.X.X.X

  - Password *allstarlink*

  - Change password

  - Log in with new password

- Initial configuration

  - sudo asl-menu

asl-menu

- Text based menu to configure server

First Time Menu

- **OS Configuration**
  - Set *root* and *repeater* password
  - Set time zone
  - Set host name and domain
  - Set DHCP or Static IP

- **Node Configuration**

Node Setup

- Select node properties

  - Password must match web site for public nodes

```
N1 Node Number      Current Node is 1999
N2 Node Password    Current password is 123456
N3 Node Call Sign   Current call sign is  WA4XYZ
N4 Radio Interface  Node Radio Interface type   dahdi/pseudo
N5 Duplex type      Current duplex type is 1
N6 Asterisk-secret  Change Asterisk manager.conf password
N9 SAVE             Save this configuration
```

  - Radio Interface (changes modules.conf)

```
I1 SimpleUSB    CM1xx USB Cards no/DSP (URIx or RA-40)
I2 USBRadio     CM1xx USB Cards with DSP (URIx or RA-40)
I3 Voter        Voting systems with RTCM's
I4 Dahdi/pseudo No radio interface or HUB node
```

  - Duplex type

```
                    ┤ Duplex type ├
0 = Half duplex with no telemetry tones
1 = Half duplex with telemetry tones (simplex node)
2 = Full Duplex with telemetry tones (repeater)
3 = Full Duplex with telemetry, but no repeated audio.
4 = Full Duplex with telemetry (Special use)
The most common types are (1) or (2)
See wiki.allstarlink.org for full documentation
```

- SAVE

Save and Start

- Initial node setup SAVE configures the following:
    - Set rxchannel in rpt.conf
    - Enable node registration in iax.conf
    - Set node number and callsign in rpt.conf
    - Set node number in extensions.conf
    - Enable statpost in rpt.conf
    - Set duplex type in rpt.conf

- In main menu do
    - Save configuration and make it live
    - Exit will reboot the server

USB Configuration

- Select tune menu to match selection
  - radio-tune-menu for USBradio
  - simpleusb-tune-menu for SimpleUSB

```
                    ┤ ASL Main Menu ├

  1  Run first-time menu
  2  Run node-setup menu
  3  Run radio-tune-menu for USBradio configuration
  4  Run simpleusb-tune-menu for SimpleUSB configuration
  5  ASL Asterisk CLI
  6  ASL Configuration Edit Menu
  7  Operating System Menu
  8  System Security Menu
  9  System Diagnostics Menu
  0  Information
```

Experiment with simpleusb.conf

- rxboost = 1 (Remove 20db attenuator)

- carrierfrom = (usb=high, usbinvert=low)

- ctcssfrom = no (just one COR and CTCSS line)

- invertptt = 1 (ptt active high)

- duplex = 1 (full duplex)

- Have ASL do pre-emphasis/de-emphasis
  - deemphasis = 1
  - preemphasis = 1

Set Levels

- Test Tx with T

- Set Rx and Tx levels


```
                    willem@mercury: /pm/raid6/linking/config

 File   Edit   View   Search   Terminal   Help

active (command) USB Radio device is [usb_29571]
1) Select USB device
2) Set Rx Voice Level (using display)
3) Set Transmit A Level
4) Set Transmit B Level
E) Toggle Echo Mode (currently Disabled)
F) Flash (Toggle PTT and Tone output several times)
P) Print Current Parameter Values
S) Swap Current USB device with another USB device
T) Toggle Transmit Test Tone/Keying (currently Disabled)
W) Write (Save) Current Parameter Values
0) Exit Menu


Please enter your selection now: 2
RX VOICE DISPLAY:
                                  v -- 3KHz        v -- 5KHz

=====================================>
```

usbradio or simpleusb?

- simpleusb does not have DSP in software
  - best for Raspberry Pi and slower hardware
  - If you always do CTCSS in hardware
- usbradio supports DSP in software
  - Can do CTCSS in the driver
  - Change rx/tx tones in software (remotely)
  - Uses CPU for DSP

Networking

- Uses UDP streams

- No configuration required if you make only outbound connections

- Inbound connections require port forwarding
  - UDP port 4569 (unless changed)

- Allow ssh access not required
  - Use caution

- NEVER open SIP ports
  - Asterisk is a full fledged PBX

Configuration files

- Comments start with ;
- Stuff following [foo] is called a stanza or section
- File macros
  - #includeifexists *filename*
- Format moderately consistent
  - Parameters set by *key = value*
  - Objects created by *key => ref*

iax.conf

- Server configuration file

- Mostly leave this alone

- Port for connections

  - [general]

  - bindport = 4569

  - Change this to have multiple servers per IP

rpt.conf

- Main configuration file for apt_rpt module

- Requires stanza for each node
  - Lots of things to set
    - channel
    - duplex
    - ID
    - commands

- Defines IP:port for all accessible nodes
  - [nodes] stanza

- Defines DTMF commands and macros

Adding private nodes

- Node definition
  - nnnn = radio@X.X.X.X:port/nnnn,NONE
    - nnnn   node number
    - X.X.X.X   IP address
    - port   port number
  - 1930 = radio@10.20.30.240:4569/1930,NONE

- Add definition in rpt.conf
  - Each nodes is a line in [nodes] stanza
  - Nodes must be defined at both ends

modules.conf

- There may be many .conf files, but only loaded modules are used
    - load => app_rpt.so ;
        - ALWAYS
    - load => chan_simpleusb.so ;
        - Only if using simpleusb

- Suppress undesired modules
    - noload => app_usbradio.so ;
        - Only if not using usbradio
    - noload => app_voter.so ;
        - Only of not using voter

manager.conf

- Controls AllMon2 access to Asterisk

- Remove *bindaddr=127.0.0.0.1* for remote access

  - Beware of public access

- secret set by asl-menu

  - Must match setting in AllMon2

extensions.conf

- [radio-secure] stanza
  - All nodes on this server must be defined here
  - exten => node,1,rpt,node
    - exten => 1961,1,rpt,1961
    - exten => 1930,1,rpt,1930
- Leave everything else alone

Voting

- Requires use of RTCMs

- Receivers must be (pretty much) identical

- Requires GPS for precise timing
  - Garmin GPS18X (TTL level)

- Estimates RSSI from audio

- Highest RSSI used (with linger)

- Audio returned to RTCM for transmit

VOTER Protocol
Voice **O**bserving **T**ime **E**xtension (for) **R**adio

- UDP Packets with voice snippets or control data

- Payload Type 1 (185 octets)

  - 0-3:   time (whole seconds, network order)

  - 4-7:   time (nanoseconds, network order)

  - 8-17:   Authentication challenge (ASCII string+null)

  - 18-21:   Authentication digest (32 bit network order)

  - 22-23:   Payload type (16 bit network order)

  - 24:   RSSI (0-255)

  - 25-184: 160 samples mu-law audio (20ms @ 8k/s)

- Payload Type 3 (188 octets) 40ms of ADPCM audio

- Four other payload types for control and timing

voter.conf

- [general]
  port = 667
  buflen = 380
  password = secret2

  [1930]
  Thorodin_A = thorsecret,transmit
  Squaw = squawsecret,master
  LeeHill = leesecret
  thresholds = 255,110=5
  linger = 6

Voter timing

- Every voter site master have GPS timing

- Master site must have GPS timing
  - Local RTCM should be used for low latency
  - Server should be fast enough to handle load
  - Enough bandwidth
    - 100kbps per voter
    - 100kbps per transmitter

voter parameters

- buflen
  - milliseconds of buffering
    - more is better for jitter but delays audio
  - 200ms for good connections
  - 500ms+ for bad connections
- thresholds = MIN_RSS=[REASSES[:LINGER]]
  - Comma separated list
  - Measured in 20ms frames (packets)
  - 255,110=5
    - Use if 255, if >110 use 5 frames, <110 switch every frame
- linger = use this client for *n* frames (default 6)

RTCM Configuration

- Access via telnet (must be a secure network!)
- Single user (remember to log out)

```
1  - Serial # (1336) (which is MAC ADDR 00:04:A3:00:05:38)
2  - VOTER Server Address (FQDN) (10.30.30.229)
3  - VOTER Server Port (667),  4  - Local Port (Override) (0)
5  - Client Password (secret1),  6  - Host Password (secret2)
7  - Tx Buffer Length (960)
8  - GPS Data Protocol (0=NMEA, 1=TSIP) (0)
9  - GPS Serial Polarity (0=Non-Inverted, 1=Inverted) (0)
10 - GPS PPS Polarity (0=Non-Inverted, 1=Inverted, 2=NONE) (0)
11 - GPS Baud Rate (4800)
12 - External CTCSS (0=Ignore, 1=Non-Inverted, 2=Inverted) (1)
13 - COR Type (0=Normal, 1=IGNORE COR, 2=No Receiver) (0)
14 - Debug Level (0)
15  - Alt. VOTER Server Address (FQDN) ()
16  - Alt. VOTER Server Port (Override) (0)
17  - DSP/BEW Mode NOT SUPPORTED
18 - "Duplex Mode 3" (0=DISABLED, 1-255 Hang Time) (1/10 secs) (0)
19 - Simulcast Launch Delay (0) (approx 200 ns, 5 = 1us, > 0 to ENA SC)
97 - RX Level,  98 - Status,  99 - Save Values to EEPROM
i - IP Parameters menu, o - Offline Mode Parameters menu
q - Disconnect Remote Console Session, r - reboot system, d - diagnostics
```

RTCM IP Parameters

- It is a good idea to change the default password
- Bootloader IP is to upgrade the firmware

```
IP Parameters Menu

Select the following values to View/Modify:

1  - (Static) IP Address (10.30.30.220)
2  - (Static) Netmask (255.255.255.0)
3  - (Static) Gateway (10.30.30.1)
4  - (Static) Primary DNS Server (10.30.30.1)
5  - (Static) Secondary DNS Server (8.8.8.8)
6  - DHCP Enable (0)
7  - Telnet Port (23)
8  - Telnet Username (admin)
9  - Telnet Password (xxxxx)
10 - DynDNS Enable (0)
11 - DynDNS Username (wb6nil)
12 - DynDNS Password (radios42)
13 - DynDNS Host (voter-test.dyndnt.org)
14 - BootLoader IP Address (10.30.30.249) (OK)
15 - Ethernet Duplex (0=Half, 1=Full) (0)
99 - Save Values to EEPROM
x  - Exit IP Parameters Menu (back to main menu)
q  - Disconnect Remote Console Session, r - reboot system
```

Offline Mode

- Makes RTCM a repeater controller when connection to server is lost

```
OffLine Mode Parameters Menu

Select the following values to View/Modify:

1  - Offline Mode (0=NONE, 1=Simplex, 2=Simplex w/Trigger, 3=Repeater) (3)
2  - CW Speed (400) (1/8000 secs)
3  - Pre-CW Delay (4000) (1/8000 secs)
4  - Post-CW Delay (4000) (1/8000 secs)
5  - CW "Offline" (ID) String (AC0KQ R)
6  - CW "Online" String (OK)
7  - "Offline" (CW ID) Period Time (6000) (1/10 secs)
8  - Offline Repeat Hang Time (15) (1/10 secs)
9  - Offline CTCSS Tone (141.3) Hz
10 - Offline CTCSS Level (0-32767) (3000)
11 - Offline De-Emphasis Override (0=NORMAL, 1=OVERRIDE) (0)
99 - Save Values to EEPROM
x  - Exit OffLine Mode Parameter Menu (back to main menu)
q  - Disconnect Remote Console Session, r - reboot system
```

Non-voting RTCM usage

- Without GPS timing the RTCM is a mixer
  - Leadville/Mosquito
    - RTCM + Mastr III repeater
    - Node and server on Thorodin
    - Works because 9ms Thorodin-Mosquito on backbone
  - Akron
    - RTCM + Mastr III repeater
    - Raspberry Pi node and server on site
    - Node linked to Thorodin server
    - Needed because 50-250ms ping times
- Standard hardware whether voter or mixer

Mixer voter.conf

- *voter.conf* used even though it is not voting

- No GPS required

- No *master* specified

- Multiple RTCMs could be used and would mix

  - Same effect as linking

- Note buflen per node

- plfilter removes CTCSS

Node 1957 - 1957 Boulder 145.430- 141.3 Lee Hill 430, Co	
Client	RSSI
Leehill14530 Mix	237

```
[general]
port = 667
buflen = 220
password = PASSWORD

[1960]
buflen=500
Akron = SECRET,transmit
plfilter = y
```

AllMon2

- Written by Tim Sawyer WD6AWP

- PHP Scripts for real time status and control

- Can be run from anywhere on the network
  - Does not need to have AllStarLink on same server

- Requires copy of astdb.txt
  - Translates node numbers when connected
  - Private nodes need to be managed

- Access control by web server
  - User logins using .htaccess and .htpasswd
  - htpasswd -d .htpasswd user

Managing Links

- Must be logged in
- Disconnect 1954 (Cheyenne Mountain)

Basic AllMon2 Configuration

- Files where web server can find them

  - /var/www/html/ typical for apache

- allmon.ini.php

  ```
  [1919]
  host=10.30.20.240:5038
  user=admin
  passwd=secret
  menu=yes
  ```

  - IP:port, user and password for each node

  - Show *menu=yes* or hide *nomenu=yes*

  - Dropdown with *system=name*

  - Nodes with *node=nnnn*

  - Voters with *rtcmnode=nnnn*

- voter.ini.php (optional)

  ```
  [COS]
  node=1954
  [Durango]
  node=1956
  [Methodist]
  node=1953
  ```

  - *node=* implies *rtcmnode=*

AllMon2 Menus

- *system*= defines menu, *[text]* defines entry
- Comma separated list shows multiple nodes

Multiple Voters

- Multiple voters can be shown on one screen
  - Mixers count as voters
  - Limited to 6 (not sure why)
    - Extras just disappear

```
[AllVoter]
rtcmnode=1930,1933,1956
system=ColCon Voter
```

Using the command line

- asterisk -rvvv

- See DTMF commands
  - Useful for debugging

- Execute commands
  - rpt fun *node* cmd (connect, disconnect, etc)
  - rpt stats *node*   (node status)
  - rpt lstats *node*   (link status)
  - rpt restart *node*   (restart apt_rpt)

See connection via DTMF

```
[Apr 19 20:58:37] NOTICE[1685]: chan_simpleusb.c:2910 simpleusb_read: Got DTMF char *
[Apr 19 20:58:38] NOTICE[1685]: chan_simpleusb.c:2910 simpleusb_read: Got DTMF char 3
[Apr 19 20:58:39] NOTICE[1685]: chan_simpleusb.c:2910 simpleusb_read: Got DTMF char 2
[Apr 19 20:58:40] NOTICE[1685]: chan_simpleusb.c:2910 simpleusb_read: Got DTMF char 9
[Apr 19 20:58:42] NOTICE[1685]: chan_simpleusb.c:2910 simpleusb_read: Got DTMF char 0
[Apr 19 20:58:42] NOTICE[1685]: chan_simpleusb.c:2910 simpleusb_read: Got DTMF char 0
[Apr 19 20:58:43] NOTICE[1685]: chan_simpleusb.c:2910 simpleusb_read: Got DTMF char 5
    -- Call accepted by 76.178.170.201 (format g726aal2)
    -- Format for call is g726aal2
    -- Hungup 'DAHDI/pseudo-1057533478'
    -- Hungup 'DAHDI/pseudo-1202083760'
    -- <DAHDI/pseudo-1187997173> Playing 'rpt/node' (language 'en')
    -- <DAHDI/pseudo-1187997173> Playing 'digits/2' (language 'en')
    -- <DAHDI/pseudo-1187997173> Playing 'digits/9' (language 'en')
    -- <DAHDI/pseudo-1187997173> Playing 'digits/0' (language 'en')
    -- <DAHDI/pseudo-1187997173> Playing 'digits/0' (language 'en')
    -- <DAHDI/pseudo-1187997173> Playing 'digits/5' (language 'en')
    -- <DAHDI/pseudo-1187997173> Playing 'rpt/connected' (language 'en')
    -- <DAHDI/pseudo-1187997173> Playing 'digits/2' (language 'en')
    -- <DAHDI/pseudo-1187997173> Playing 'rpt/node' (language 'en')
    -- <DAHDI/pseudo-1187997173> Playing 'digits/2' (language 'en')
    -- <DAHDI/pseudo-1187997173> Playing 'digits/9' (language 'en')
    -- <DAHDI/pseudo-1187997173> Playing 'digits/5' (language 'en')
    -- <DAHDI/pseudo-1187997173> Playing 'digits/7' (language 'en')
    -- <DAHDI/pseudo-1187997173> Playing 'digits/1' (language 'en')
    -- Hungup 'DAHDI/pseudo-1187997173'
```

Disconnect from asterisk

- rpt fun *node*   commandkeys
  - Can be used to connect, disconnect, run macros, ...

```
repeater*CLI> rpt fun 29571 *129005
    -- Hungup 'IAX2/76.178.170.201:4569-202'
    -- Hungup 'DAHDI/pseudo-223005896'
    -- Hungup 'DAHDI/pseudo-277258805'
    -- <DAHDI/pseudo-999332282> Playing 'rpt/node' (language 'en')
    -- <DAHDI/pseudo-999332282> Playing 'digits/2' (language 'en')
    -- <DAHDI/pseudo-999332282> Playing 'digits/9' (language 'en')
    -- <DAHDI/pseudo-999332282> Playing 'digits/0' (language 'en')
    -- <DAHDI/pseudo-999332282> Playing 'digits/0' (language 'en')
    -- <DAHDI/pseudo-999332282> Playing 'digits/5' (language 'en')
    -- <DAHDI/pseudo-999332282> Playing 'rpt/remote_disc' (language 'en')
    -- Hungup 'DAHDI/pseudo-999332282'
    -- Hungup 'DAHDI/pseudo-1875772093'
repeater*CLI>
```

Things to explore

- Remote base
  - Change channels via GPIO
  - link2link=yes in rpt.conf to prioritize link
- Macros
  - Do lots of things with one command
  - Configure in rpt.conf
- Lots of other things in rpt.conf
  - Telemetry
  - Custom audio
  - ...