DMRGateway Technical Overview
INAD

- Overview
  - The goal
    - Allow a user on the ASL analog network to communicate with a user on a DMR network.
  - The networks
    - DMR - two time slot TDMA RF network
      - IPSC
        - Masters
          - Peers register with a master and the master then replies with a list of all peers including the master
        - Peers
          - Communicate with peers in the list even if master drops off the network
        - IPSC frames
          - Transmissions between peers it is composed of IPSC frames. Each frame contains a frame type, peer ID, subscriber ID and a payload. For voice traffic the payload is AMBE data.
    - AllStar Asterisk - Analog network with central node number to IP server.
      - Asterisk servers can host multiple nodes
      - IAX is a communications protocol native to the Asterisk software
      - ASL communicates between servers with the IAX protocol. Audio codecs are negotiated at link time between nodes.
  - The Metadata
    - AllStar
      - Callsigns
        - Call signs are assigned by the local regulatory authority
      - Node numbers
        - Public Node numbers are assigned by allstarlink.org.
    - DMR
      - Radio IDs
        - Issued by DMR-MARC by world wide agreement
        - Numeric (defined by manufacturers for commercial use)
        - Repeaters (6 digits)
        - Users (7 digits)
      - Slots - two time slots (TS)
      - Talk Groups (TG)
        - Segregate traffic on TS
          - Only 1 TG can be in use at a time on a given TS
        - Mutually agreed on TG numbers

- ○ The audio
  - ■ PCM
    - ● 8 KHz 16 bit mono (160 samples @ 50 per second)
  - ■ AMBE
    - ● 49 bit frames
    - ● 20 ms frame rate
    - ● OTA adds FEC for 72 bit payload

- ● DMRLink - Open source Python application used to build IPSC networks created by Cort, N0MJS. DMRlink is composed of a base library, dmrlink and several applications, bridge, playback, play_group, log record and ambe_audio. Multiple applications can be run at the same time.
  - ○ ambe_audio.py - DMRlink application for extracting AMBE frames
    - ■ dmrlink.cfg defines the master or peer to communicate with
    - ■ ambe_audio.cfg defines IP address and ports and Metadata info
    - ■ Decode
      - ● Decompose frame into TS, TG, Peer ID, Subscriber ID and AMBE
      - ● if the frame passes the tgFilter then send the AMBE to DMRGateway
    - ■ Encode
      - ● Listen for packets from DMRGateway
      - ● Template driven frames have type HEAD, VOICE1-4 and TERM
      - ● For each transmission
        - ○ Produce a HEAD frame with proper Metadata
        - ○ Stream a series of round robin VOICE frames
        - ○ Produce a final TERM frame at the end
    - ■ ambe_audio.cfg defines all the settings for the ambe_audio application. The cfg file is located in the same directory as the .py file.
    - ■ Remote Control
      - ● ambe_audio can be commanded to change several parameters without restarting the application.
      - ● tgs = x,y,z - Set the talk groups that will pass the tgFilter and be sent to DMRGateway
      - ● reread_subscribers - read a newer version of the subscriber_ids.csv file into memory. This file is used to translate DMR IDs into call signs.
      - ● reread_config - reread the ambe_audio.cfg file from disk. Used to reset the ambe_audio application to its initial state.
      - ● txTg = # - Set the talk group to assign all audio from DMRGateway
      - ● txTs = # - Set the time slot (1 or 2) to assign audio from DMRGateway
      - ● section = XX - Reread the ambe_audio.cfg file and make the named section active rather than the one defined within the cfg

file. This is used to programmatically change the applications characteristics between several named groups of settings.

- DMRGateway
  - DMRGateway is a stand alone application used to encode PCM into AMBE and decode AMBE back into PCM. The application is written in C++ and can run on Linux and OSX operating systems (It has not yet been ported to Windows).
  - DV3000
    - The encoding and decoding uses the AMBE3000, available as a PiDV add on board for the Raspberry Pi or the ThumbDV USB dongle. The AMBE3000 is programmed with the specific rate control words to match the AMBE being produced. For DMR this is a total rate of 3600 bps with a speech rate of 2450 bps and FEC at 1150 bps.
    - USB or GPIO
      - ThumbDV devices appear as virtual com ports at 460800 baud. Older devices used 230400 baud. On Linux, the device will be found in the /dev/ttyUSBx tree. No additional drivers are needed.
      - PiDV devices connect to the serial and GPIO pins of a Raspberry Pi. Users should use the AMBEServerGPIO application with the device. Future updates may include direct serial support.
      - For more information: http://nwdigitalradio.com/thumbdv-and-dv3000-resource-page/
    - AMBE to PCM
      - The AMBE from IPSC is 49 bit non-interleaved, non-FEC
      - The AMBE3000 chip set requires 72 bit interleaved FEC
        - Interleave the 49 bits into 4x24 bit arrays
        - Golay the first 12 bits generating a 23 bit result
        - Add in the final parity bit
        - Golay the next 12 bits creating another 23 bit result
        - Add the final 11 bits + 14 bits (no ecc added)
        - Demodulate the result into 72 bit values
        - Send the 72 bit frame to the AMBE3000 to decode into PCM
    - PCM to AMBE
      - Send PCM to AMBE3000 to encode into 72 bit frames
      - Deinterleave into 4x24 bit arrays
      - Demodulate the result
      - Select the AMBE from the ecc to get 49 bits
    - Audio shaping
      - DMRGateway also has the ability to manipulate the PCM frames with AGC and band pass filtering.
    - Dongle mode
      - DMRGateway also has the ability to use a simple speaker and microphone to communicate with users on the DMR network. The

configuration file enables this mode with the *useMicrophone* setting and may use the vox settings to define trigger and delay values. Dongle mode is still under development, but may be fun to play with. PTT is controlled either by using the keyboard to toggle the transmit state or by using the vox. If using the keyboard, you will need to run DMRGateway in the foreground.
- ■ Local Monitor
    - ● You may listen to the DMR audio locally by setting the *outputAudioDevice* in the ini file to a valid OSS audio device. Once set up, all decoded DMR audio will be output. Use the alsamixer application to adjust audio levels.
- ○ DMRGateway.ini
    - ■ All settings for DMRGateway are defined in the .ini file. The ini file is normally located in the /etc directory, however you may invoke the DMRGateway application with a command line parameter to load a specific path. The ini file defines IP address and ports, audio devices and audio shaping values.
- ● Asterisk / Allstar Link
    - ○ app_rpt is a asterisk application
    - ○ USRP channel driver
        - ■ Originally created as a SDR to ASL interface.
        - ■ Communicates with the outside world via
            - ● Two UDP streams (Transmit and Receive)
            - ● Each stream is composed of 8 KHz PCM audio
            - ● PTT and sequence numbers are used in a wrapper
    - ○ rpt.conf
        - ■ rxchannel = usrp/ip:txPort:rxPort

Glossary

AllStar	Radio Over IP network built with Asterisk <allstarlink.org>
AMBE	Advanced Multiband Excitation
AMBE3000	Chip set developed by DVSI used in the PiDV and the ThumbDV
ASL	AllStar Link
Asterisk	VOIP (ROIP) Application
Debian (Jessie)	GNU/Linux Distribution
DIAL	AllStar Asterisk on Debian Jessie
DMR	Digital mobile radio
DMRlink	<https://github.com/n0mjs710/DMRlink>
DMR-MARC	DMR-Motorola Amateur Radio Club
DVSI	Digital Voice Systems, Inc.
FEC	Forward Error Correction
Golay	Linear error correcting code
Parity	Used for error detection
IAX	Inter-Asterisk eXchange
IPSC	IP Site Connect
INAD	Your guess here
Mototrbo	Motorola DMR Tier II and Tier III implementation
NW Digital Radio	Manufacturer of the PiDV and ThumbDV
OSS	Open Sound System (Older Linux audio subsystem)
PCM	Pulse Code Modulation
Peer ID	Access point ID in IPSC Network
PTT	Push to Talk
Python	An open source programming language
ROIP	Radio Over IP (Analog)
SDR	Software Defined Radio
Subscriber ID	Radio ID defined in radio programming software
TCP	Transmission Control Protocol
TDMA	Time Division Multiple Access
UDP	User Datagram Protocol
USRP	Universal Software Radio Peripheral <www.ettus.com>
VOIP	Voice Over IP (Analog)