Using AREDN Software to Create a Ham Radio IP Network

Updated 10/16/2022 – Vers. 5.0

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AREDN™
AMATEUR RADIO EMERGENCY DATA NETWORK

Ham Radio IP Networking with AREDN Software

Comparing speeds (modulation rates, not throughput)

- Packet radio is 1200 baud (1 baud = 1 bit/second)
  - That's .0012 Megabits/second (!)
- PACTOR IV is up to 5,200 bits/second (but not normally allowed in the U.S.)
- VARA FM (software modem) is up to 25,000 bits/second
- Ham radio network links can be more than 100 Megabits/second
- AREDN networking uses commercially available access points from Ubiquiti, TP-Link, Mikrotik and GL.Inet
- The access points are loaded with custom firmware from AREDN; they become ham radios.
- They can then be used to create a ham radio IP network (the "Hamnet")

Amateur Radio Emergency Data Network (AREDN) Software as of 10/16/2022

Supports:

- Four brands of equipment, 70+ different models, across four ham bands
- Internet tunneling between nodes, to bridge RF gaps (requires addition of Mikrotik hAP AC Lite to shack network)
- Allows operations in Part 97 (ham) channels
- MIMO (Multiple Input / Multiple Output) + 802.11n operation - enhances throughput substantially compared to older devices
- The software provides DNS & DHCP services, route discovery and routing information – makes it relatively easy to get set up and connected.

The Digital Networking Bands

- **902-928 MHz**
  - not used much in urban and suburban areas (very noisy): only one 5 MHz wide channel. We're secondary on that band, the gear is relatively expensive and getting hard to find.

- **2.4 GHz – 2300-2450 MHz**
  - Only one usable 10 MHz wide Part 97 channel (Channel -2); Channel -1 may work OK away from cities.
  - Noisy due to splatter from poorly designed Part 15 wireless gear

- **3 GHz – 3300-3500 MHz**
  - The good news: it's all ours! No U.S. Part 15 in this band
  - The bad news: we have to buy export equipment and it's almost double the price of 2 or 5 GHz equipment
  - The worse news: in April 2022, the FCC gave half of it to the 5G carriers; we'll find out the fate of the other part of the band in the future.

- **5 GHz Band – 5650-5925 MHz**
  - Lots of channels.
  - The Part 97 band overlaps a lot of Part 15 channels, which can be useful for spreading traffic out.
  - We're secondary in this band. In October of 2020 the FCC took away primary occupancy of this band from the DOT (Department of Transportation). They'll be allowing Part 15 users to spread into the entire band in the near future. FCC is proposing other occupants, too. Expect noise floor to rise over time.

Line of Sight

"Microwaves can go ~~15~~ miles or through one tree"

~~25~~

35

Two's Company

Tree's a Crowd...

Wireless Access Points running AREDN software

They’re like handie-talkies:

- They’re low power (typically 600 milliwatts)
- They’re limited to line of sight
- So they usually communicate through hilltop sites
- If your node hears multiple hilltops, it will always choose the best signal for its default route. So there’s no point in using an omni antenna. A dish pointed at the strongest node is recommended.

Networking is a modern ham radio activity

But it's just infrastructure. It doesn't do anything…

It's all about the “Services”

- **Services = things you can actually use**

Some examples:

- Messaging/Email
- Keyboard to keyboard (text)
- Voice
- Video
- Document editing/management
- File Sharing Services
- Web servers
- Repeater linking
- ***Anything else you can think of subject to the Part 97 regulations***

Messaging

The future of EmComm is not voice, but rather data

Plain old Email

- Email servers & clients, using standard SMTP
  - Thunderbird, etc.
  - Web clients are available (e.g., Roundcube)
- But Winlink and a ham radio network were made for each other!

Winlink
(Winlink Global Radio Email)

A worldwide messaging system, originally for boaters. Can use:

- **On HF**
- ALE (Automatic Link Establishment)
- AX.25 Packet Radio
- Robust Packet (proprietary SCS protocol)
- PACTOR, PACTOR 2, PACTOR 3, PACTOR 4*
- VARA/HF (software modem)
- ARDOP (older generation software modem; falling out of use)

*Only legal in the U.S. during emergencies, authorized by FCC

Winlink

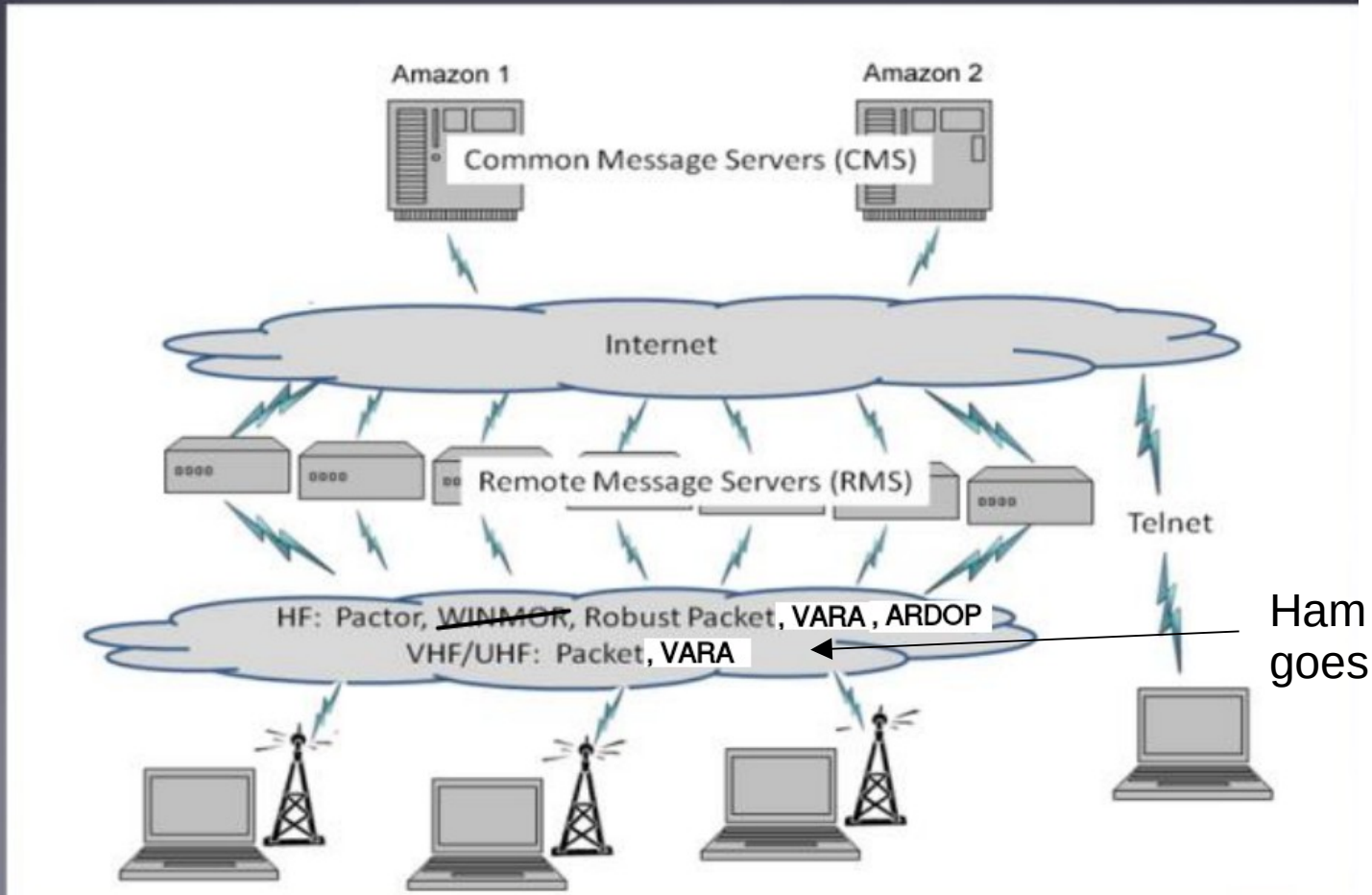
On VHF

- AX.25 Packet Radio
- APRS
- VARA/FM
- AREDN network (recently added)
  - much faster, no digipeating required

- Has a large set of standardized messaging templates. (e.g. ICS, USGS, FEMA)

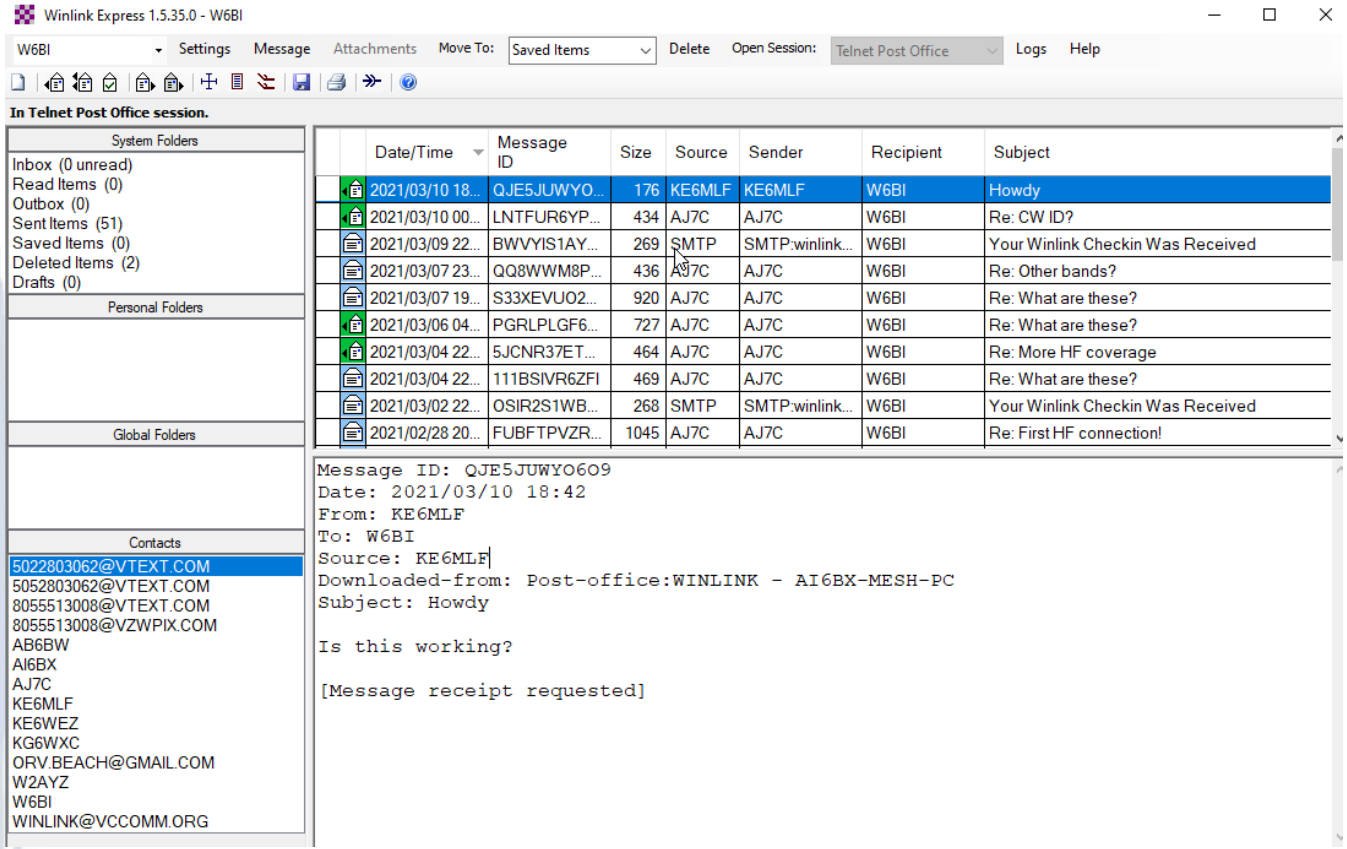
Winlink Architecture (Conventional Mode)

- CMS
- RMS (gateway)
- Client (you)



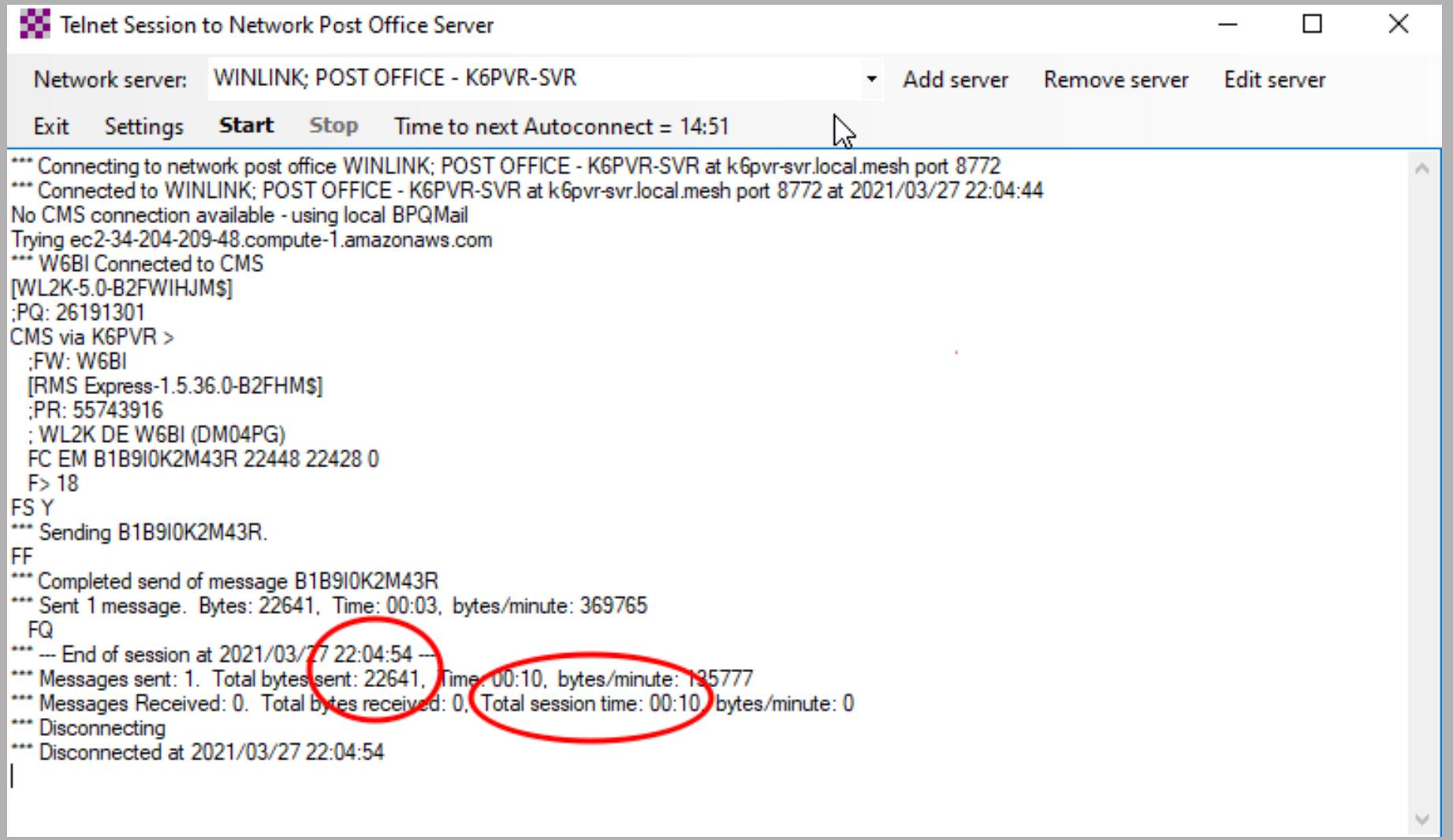
Ham networking goes here

Winlink Express Client



Setup can be complex, depending on how many modes your station is set up for: Pactor, VARA, AX.25 packet, mesh network, etc.

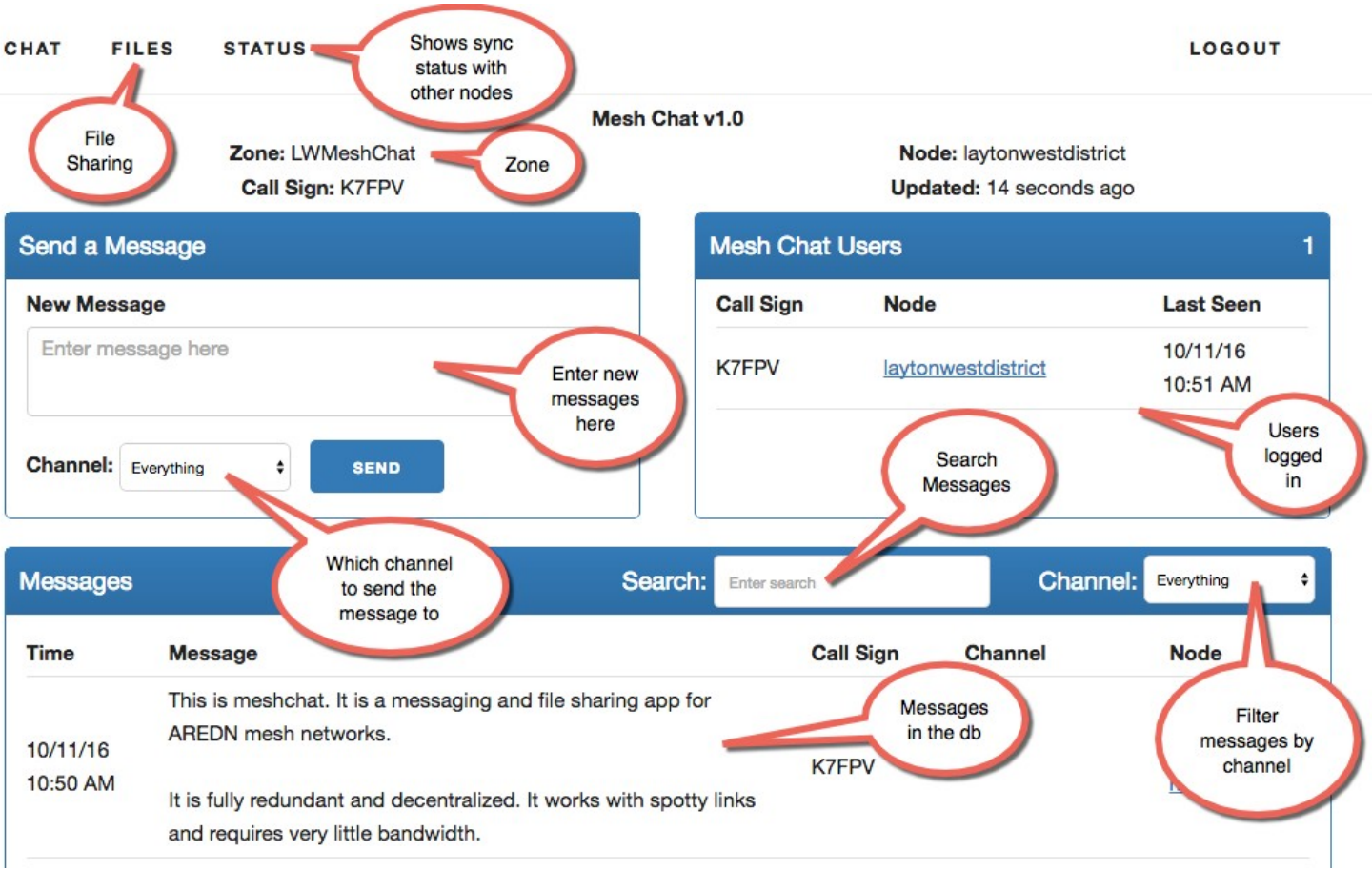
22 kbytes transferred via mesh network in 10 seconds!



Keyboard to Keyboard

- **MeshChat**
  - Runs on a Raspberry PI
  - Multiple channels can be created
  - Automatically finds other MeshChat servers
  - Web-based interface
  - Built-in “dropbox”

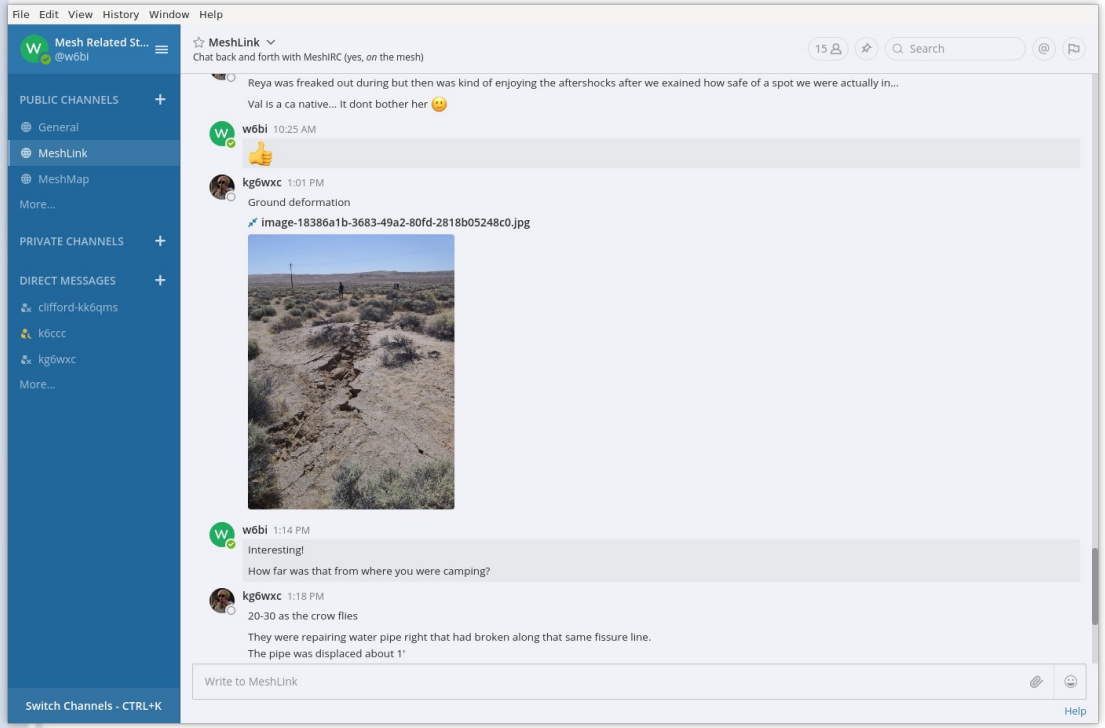
MeshChat example



Communication “Hubs”

- Mattermost & RocketChat - like Slack
- Text & pictures
- Multiple channels available
- Web access + Windows, IOS, MacOS, and Android apps available

Mattermost



- Screenshot of ham network Mattermost server in Ventura County
- Also linked to another Mattermost server in San Bernardino County (100 air miles, 150 network miles away)
- Also linked to a Mattermost server on the Internet

VOIP (Voice Over IP w/Phones)

- Phone calls over the ham radio network
- Old photo, pre-deployment:
  - Old Cisco VOIP phone $25
  - Grandstream VOIP phone switch ~$250

- VOIP PBX installed in mountaintop repeater building (K6PVR – Sulphur Mountain, Ojai, California)
  - Voice mail, conference calls, etc
- About 30 extensions: ham and served agencies (PD EOCs, hospitals, etc.)

VOIP (Voice Over IP Phones)

- Grandstream GXP 1625 VOIP phone (about $35) Two lines, POE-capable
- Other brands and models will work (Be careful buying old phones – make sure they can work with the SIP protocol; some are proprietary).
- Showing a missed phone call
- Showing one or more voice messages waiting

Another VOIP PBX

- Raspberry Pi 3 running FreePBX
- Deployed to the adjacent valley; trunked to first PBX
- Offers extensions, voice mail, conference bridges, etc.

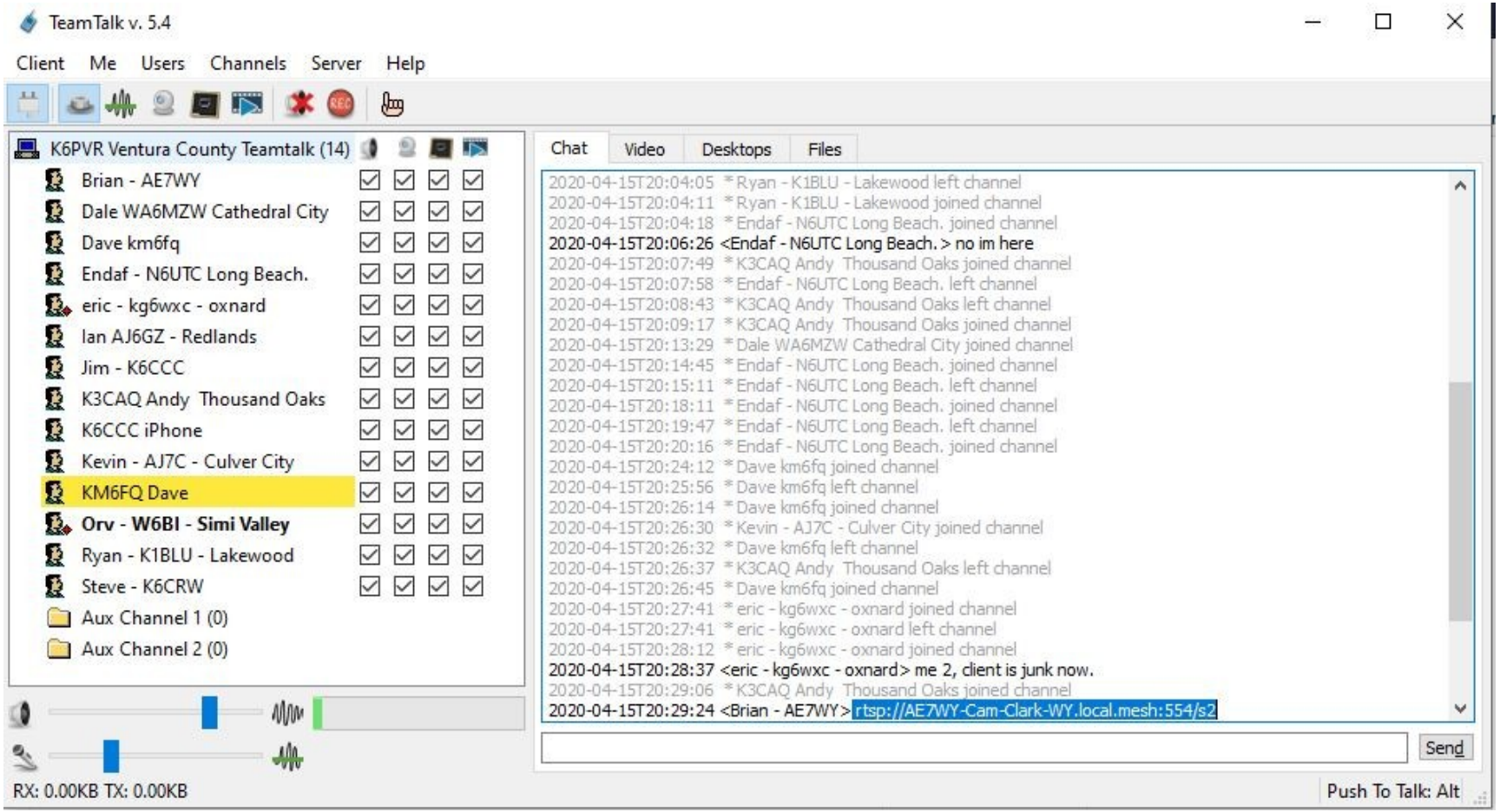
Collaboration Servers!

- Like the gamers use to coordinate their teams
- Voice and/or video chat. Very useful – and fun!
- TeamSpeak, Mumble, TeamTalk, etc.
- Teamtalk provides these features:
  - One to one chats
  - Many to many (chat rooms)
  - Can set up as many channels as necessary
  - Multiple, **simultaneous** conversations possible – all **full duplex** (you can interrupt whomever's speaking :-D)
  - Speaker/microphone or headset (**HIGH quality audio**; not limited to 300-3,000 Hz like regular ham radio)

Collaboration Servers! (cont.)

- PTT, VOX or open mic (each audio stream uses about 30 kbps – minimal load on a healthy network)
- File sharing and desktop sharing are also available
- The Teamtalk server runs nicely on a Raspberry Pi (RPI 3: typically < 10-15% CPU utilization)
- Clients available for Windows, Debian Linux, MacOS, IOS, and Android

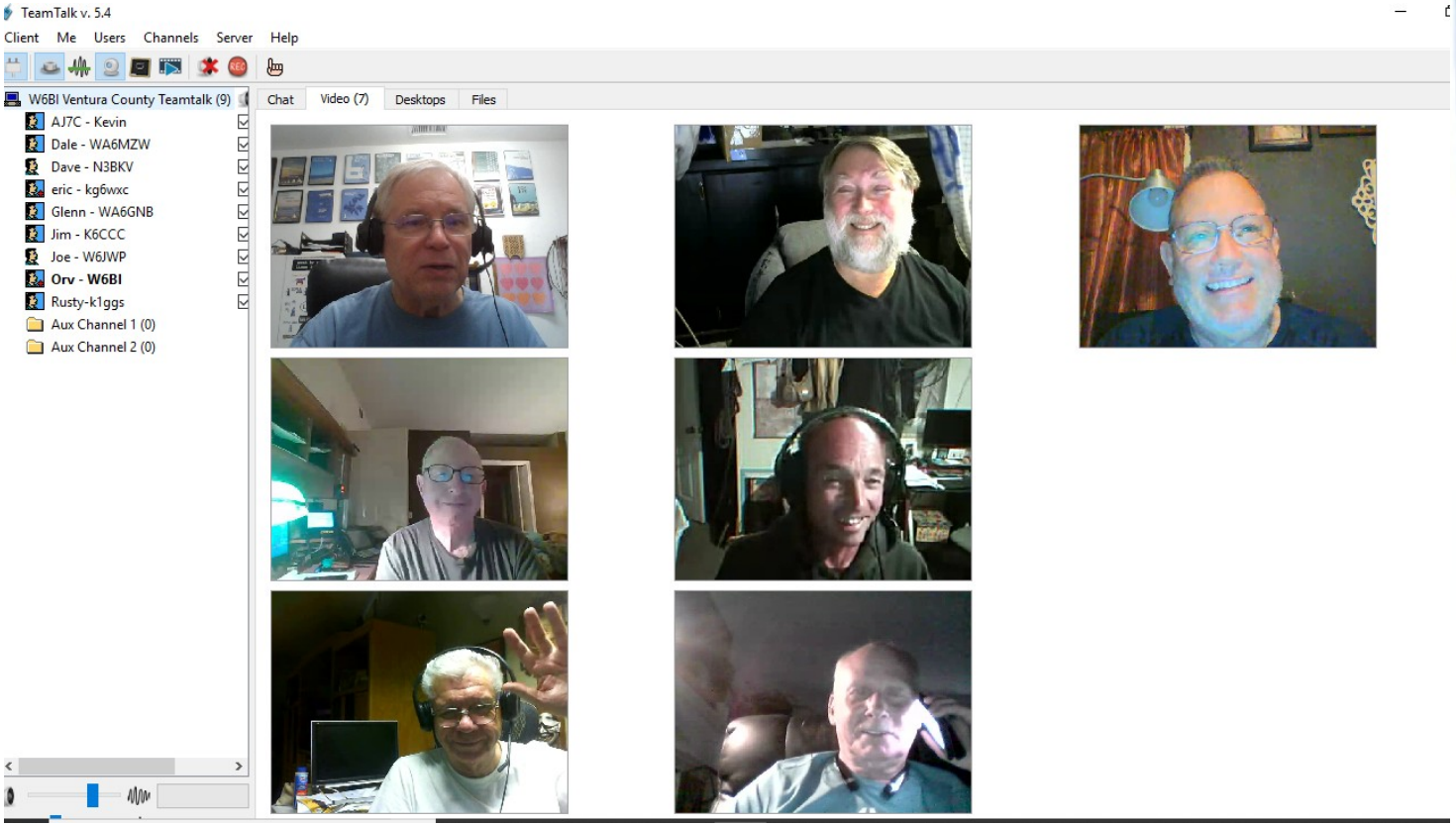
Teamtalk Weekly Net – Call of person talking has green background; when they unkey it turns yellow



Teamtalk Net

Video can be bandwidth-heavy. It's optional

Aux channels; switch to one by double-clicking
Green – who's talking
Yellow – who talked last



Video – Webcam Examples

Field day setup, 2016
As the crow flies, about seven miles. But two ranges of hills were in the way.
Via network - 3 hops on 2.4 & 5.8 GHz, about 40 miles total path length.

Typical PTZ camera view

The Thomas Fire – Ventura, CA Dec 2017.
Streamed to YouTube for wide viewing

The Woolsey Fire – Thousand Oaks, CA 11/2018
Also streamed to YouTube

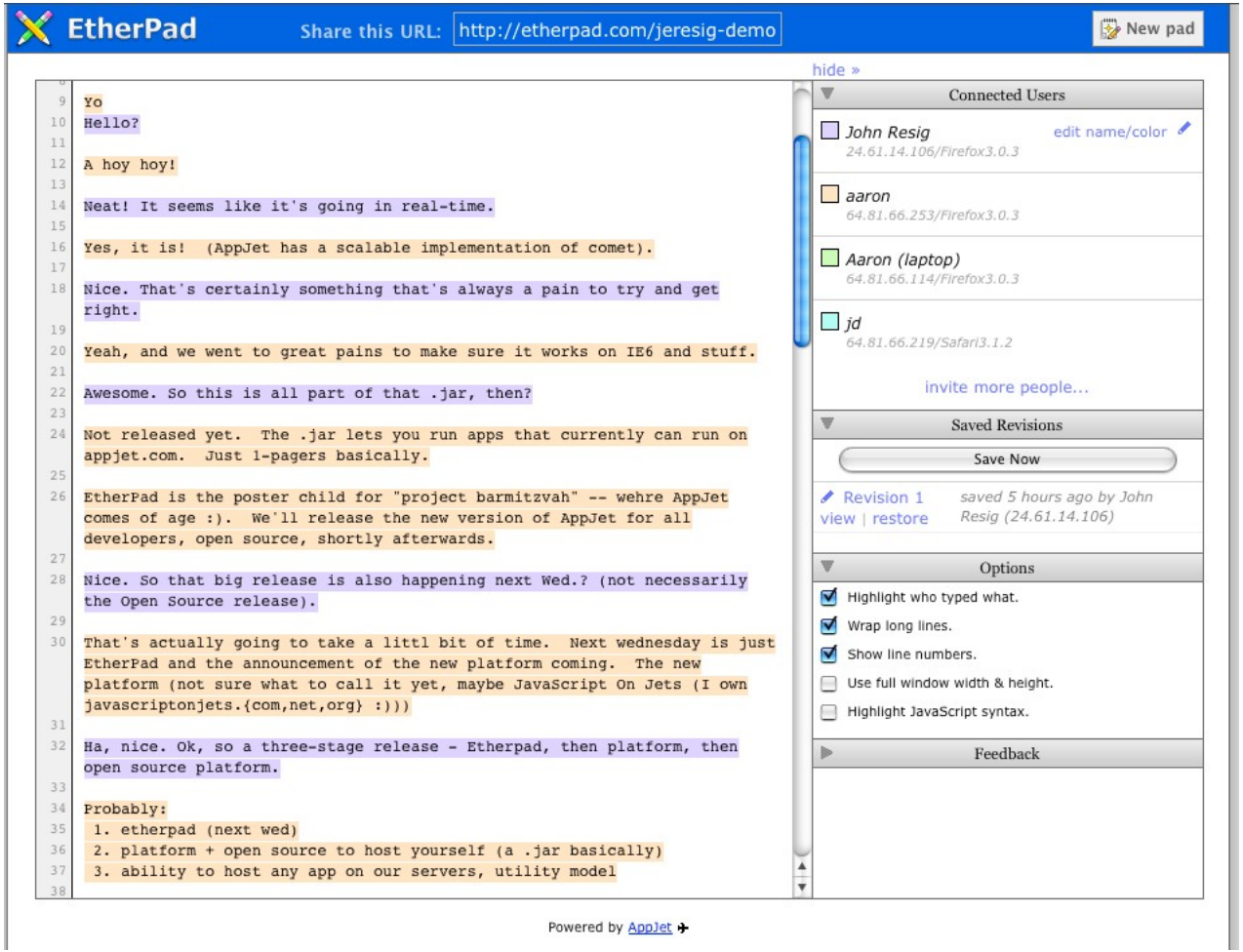
The Woolsey Fire – Thousand Oaks, CA 11/2018
Also streamed to YouTube

Brush fire in Santa Susana Pass – right below radio site. Also streamed to YouTube

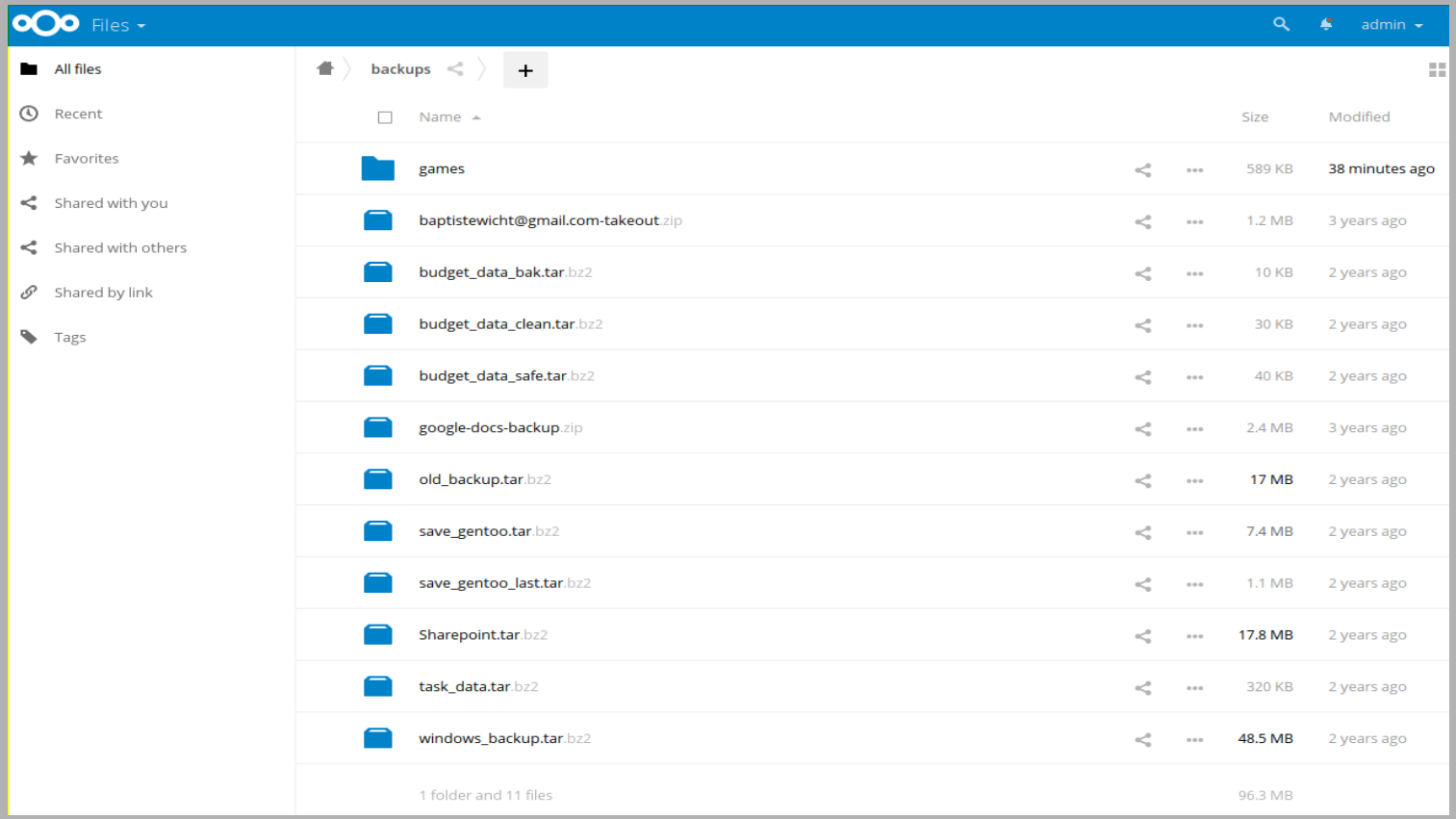
Document Sharing

- Etherpad - like Google Docs (but no spreadsheets)
- NextCloud cloud storage
- Several others

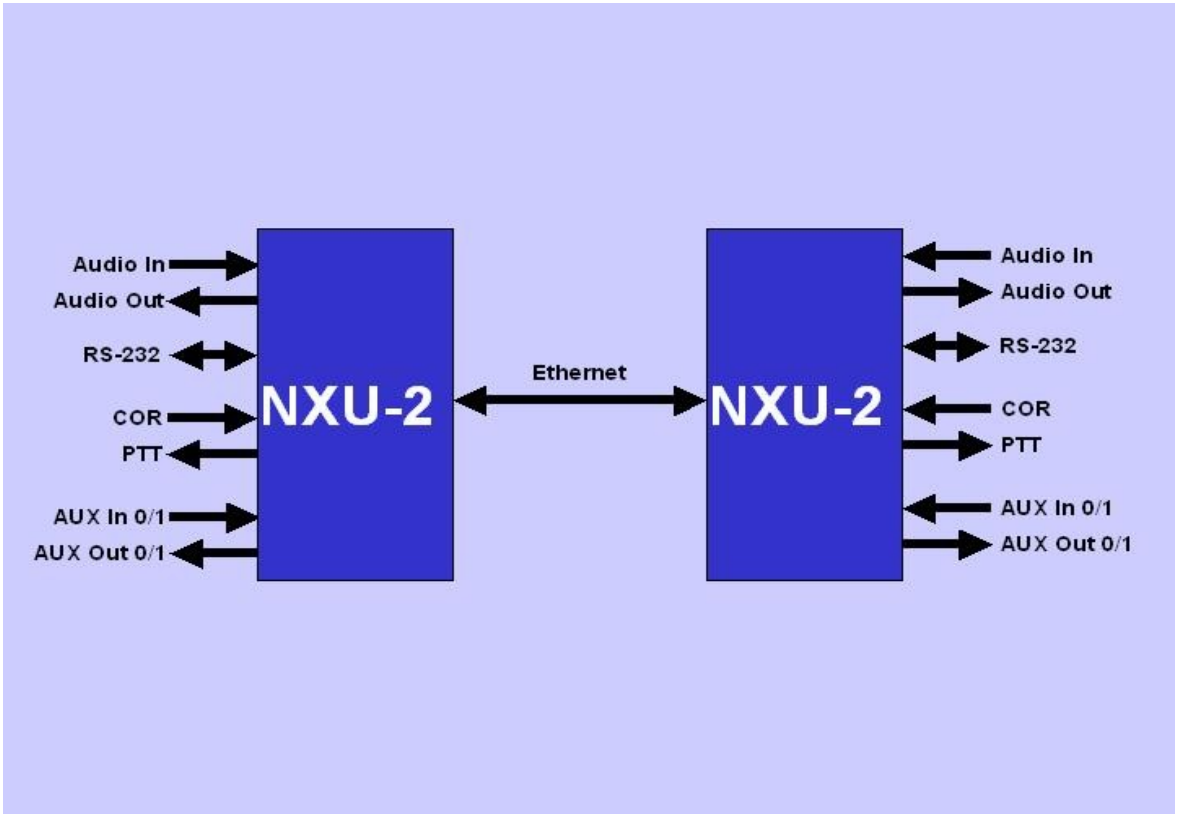
Etherpad example (not ham)



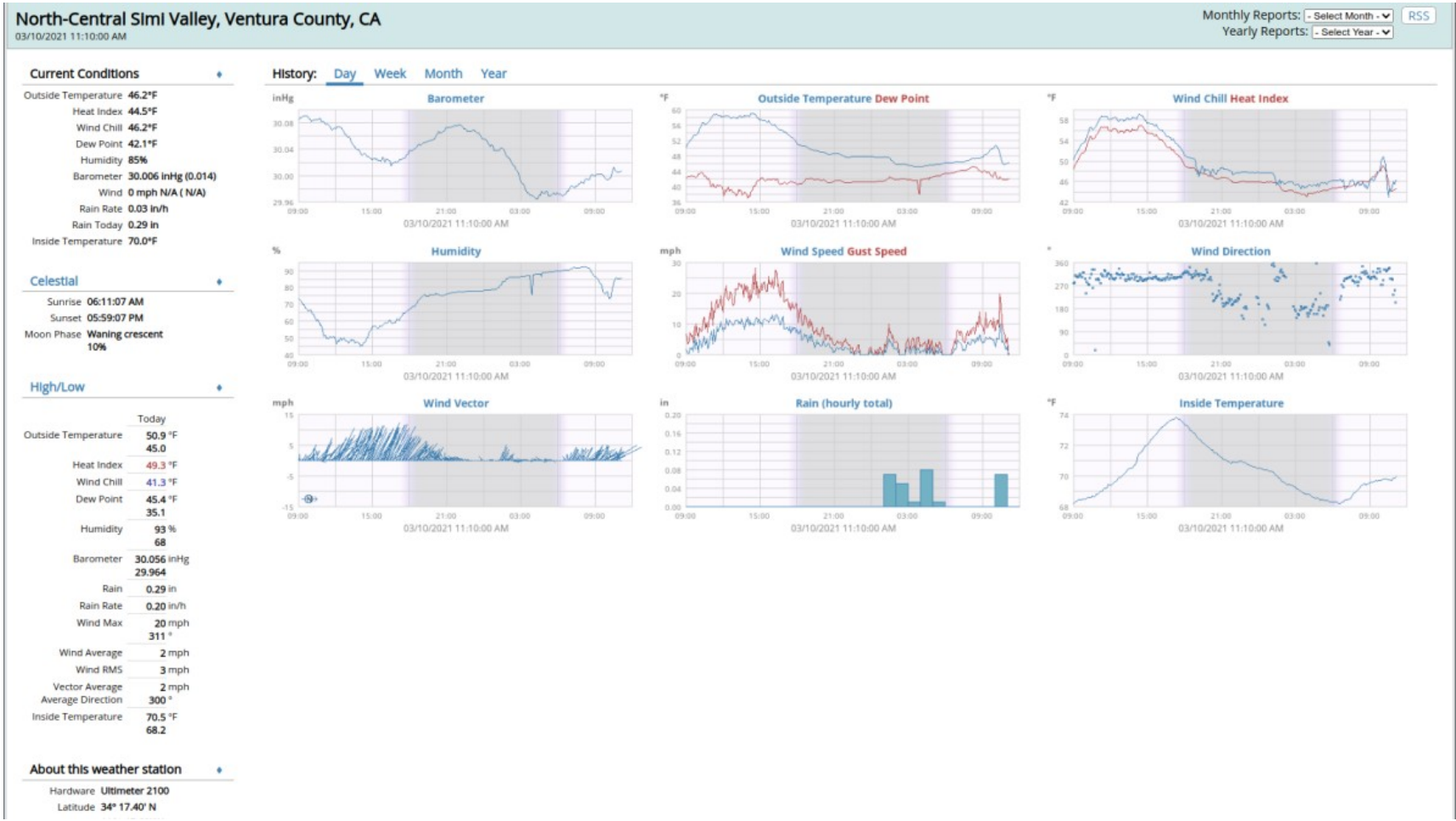
NextCloud – a drop box



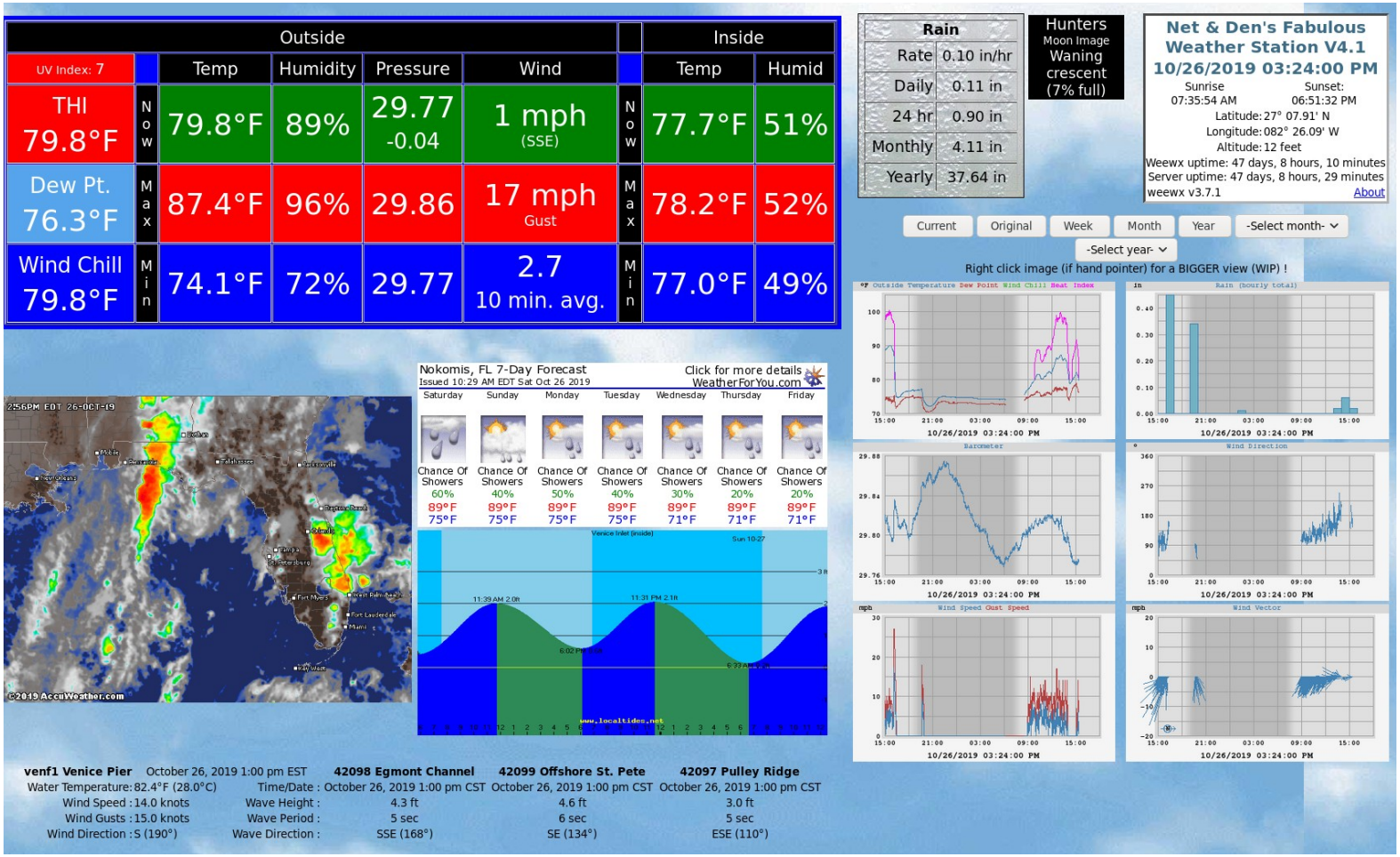
RoIP (Repeater Over IP) repeater linking via equipment from JPS Communications, SkyMira, etc.
Allstar, Dstar & DMR repeaters can be linked via the hamnet, too



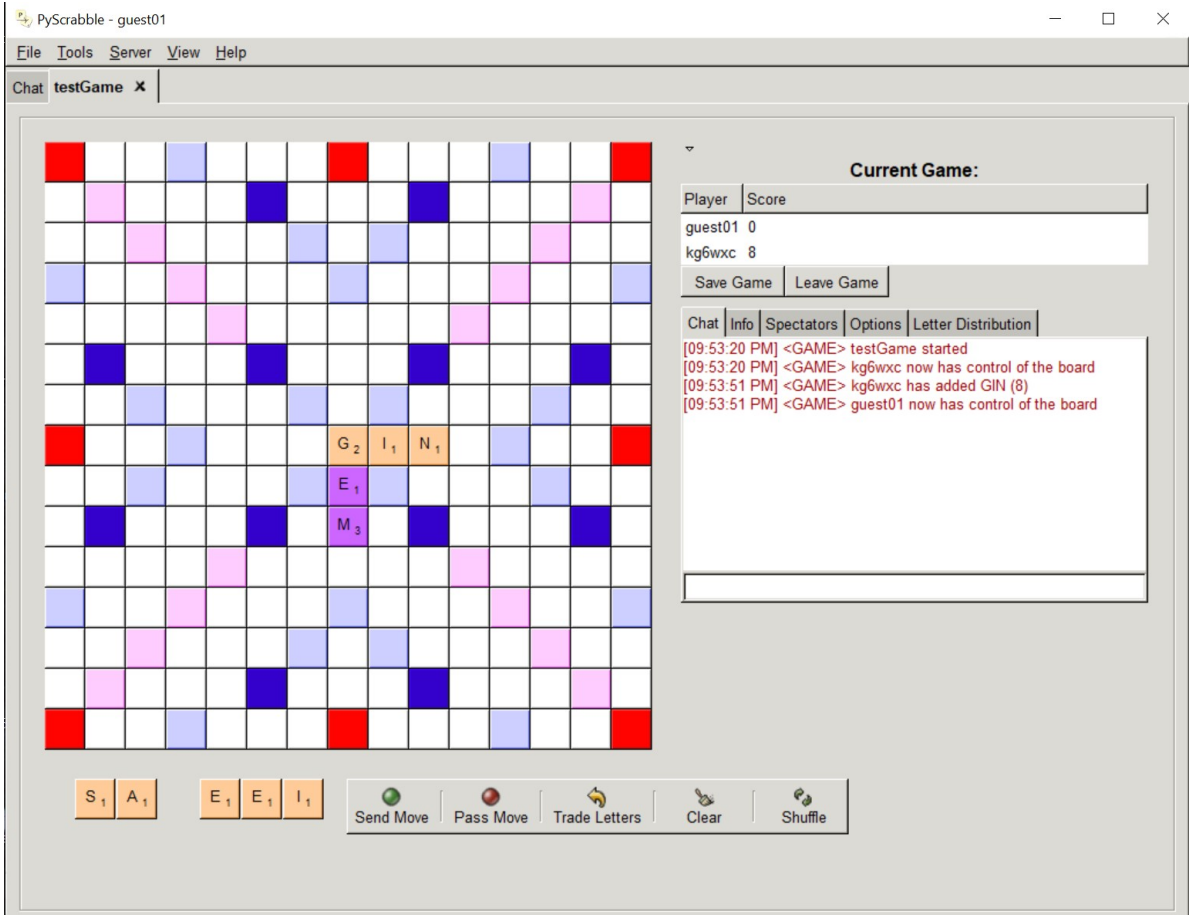
Put your Weather Station on the hamnet!
Example uses Weewx software (weewx.com) on an RPI



Weewx gone wild - highly-customized



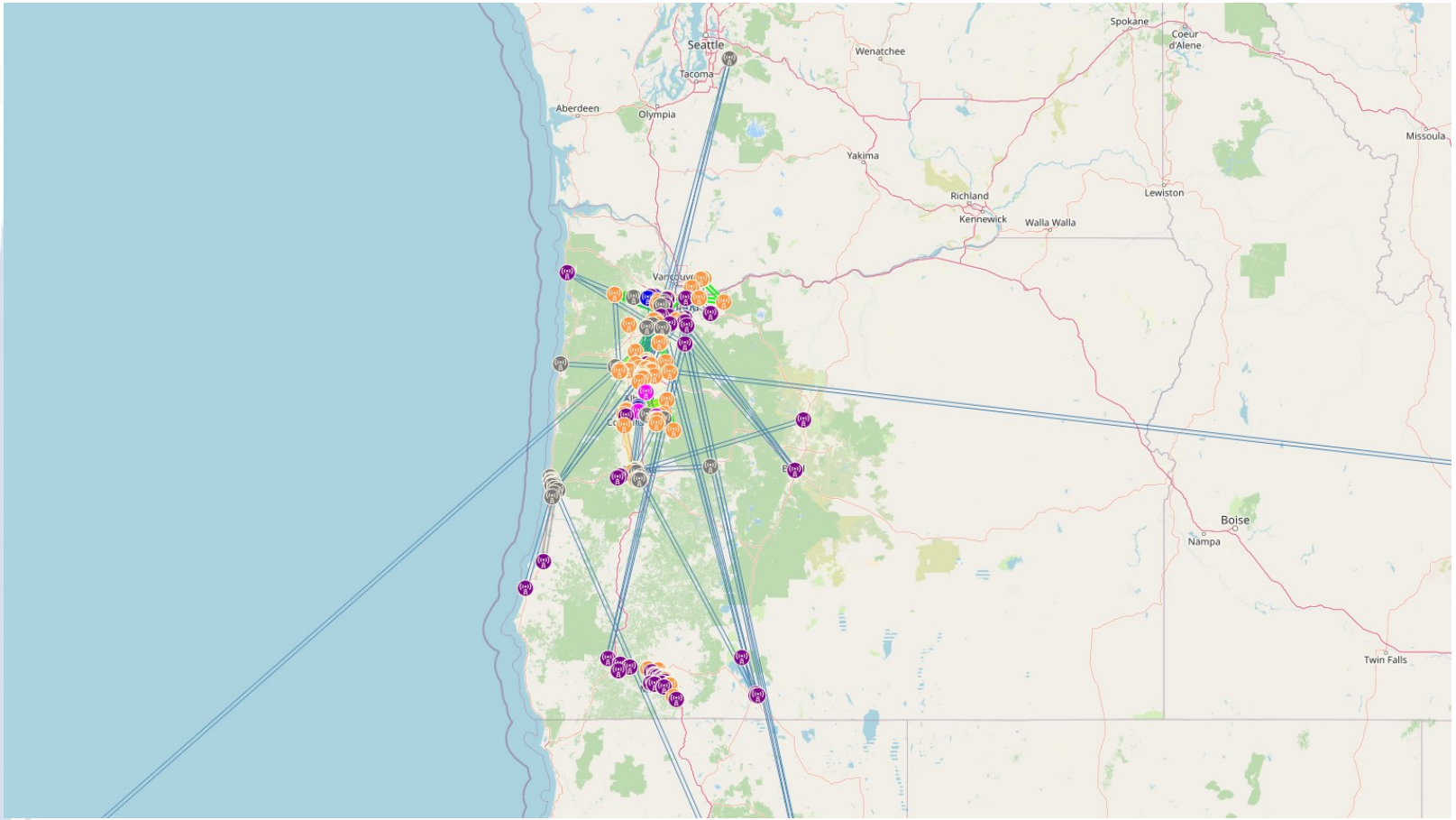
Gotta have some fun!
Scrabble server, running on hamnet!



bzflag (“tank”) game!

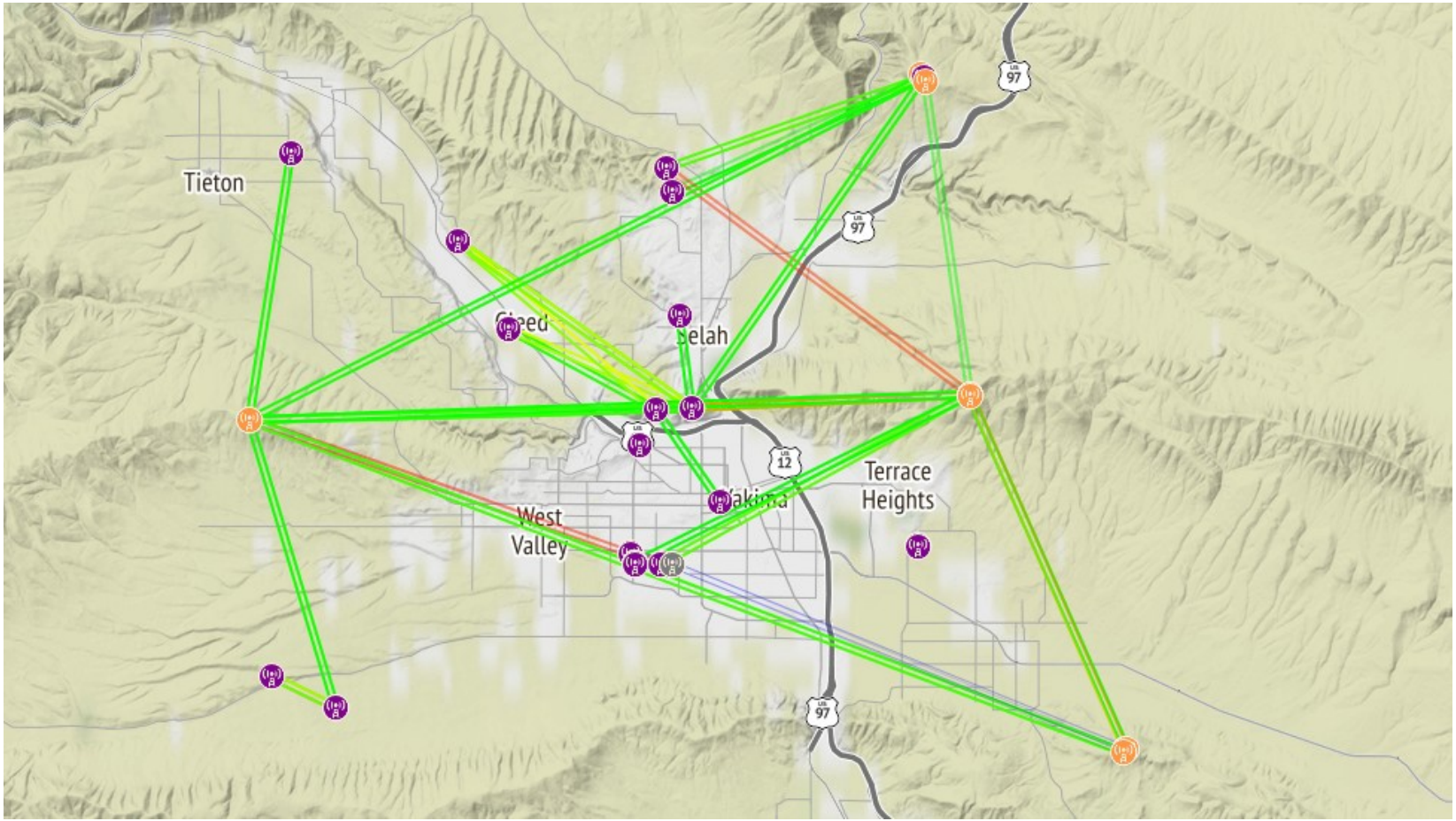
Texas Hold ‘Em server :-)

Network maps from KG6WXC mapping software – Washington/Oregon

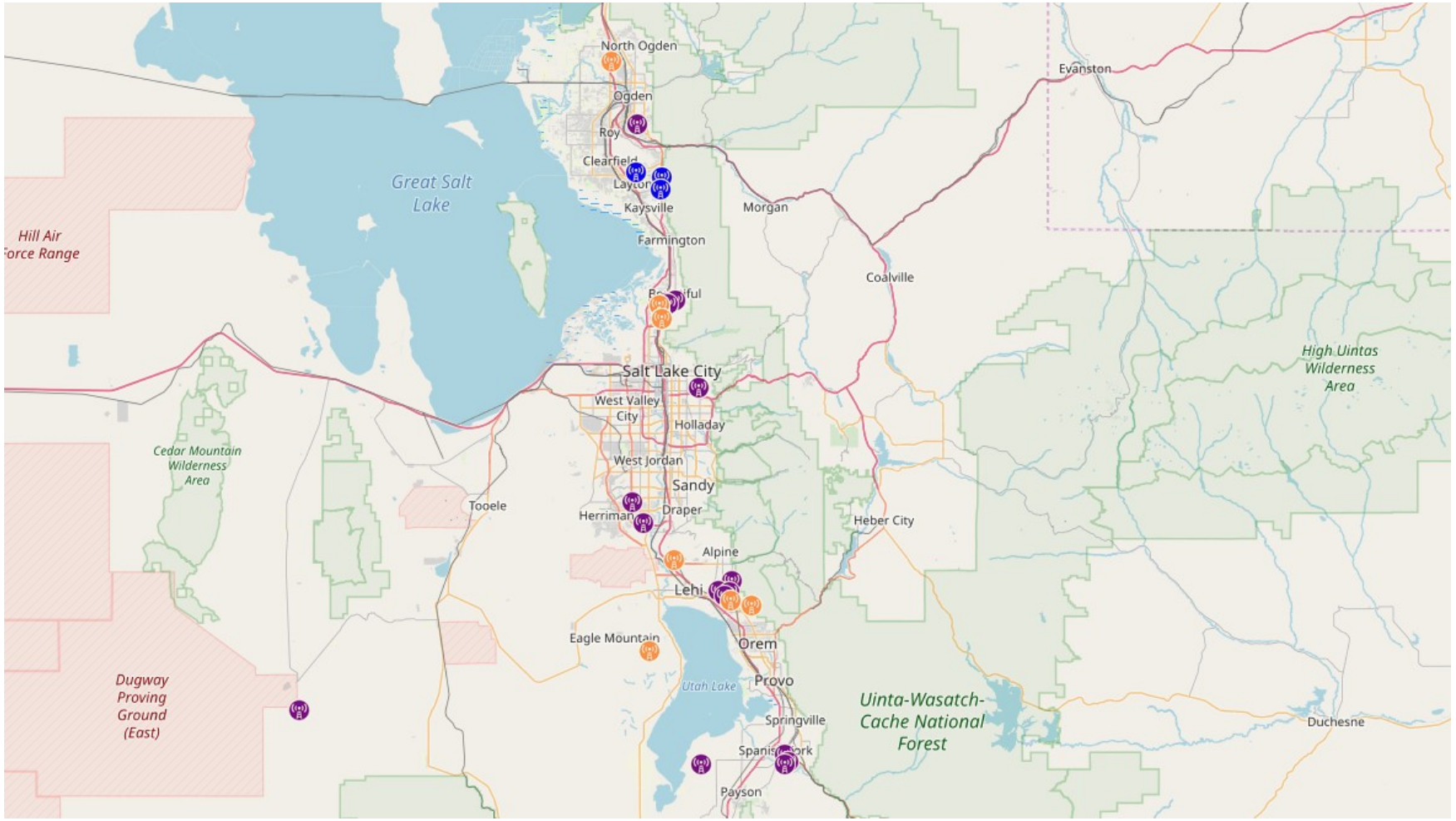


Orange – 5 GHz
Purple – 2 GHz
Blue – 3 GHz
Pink 900 MHz
Grey – no RF

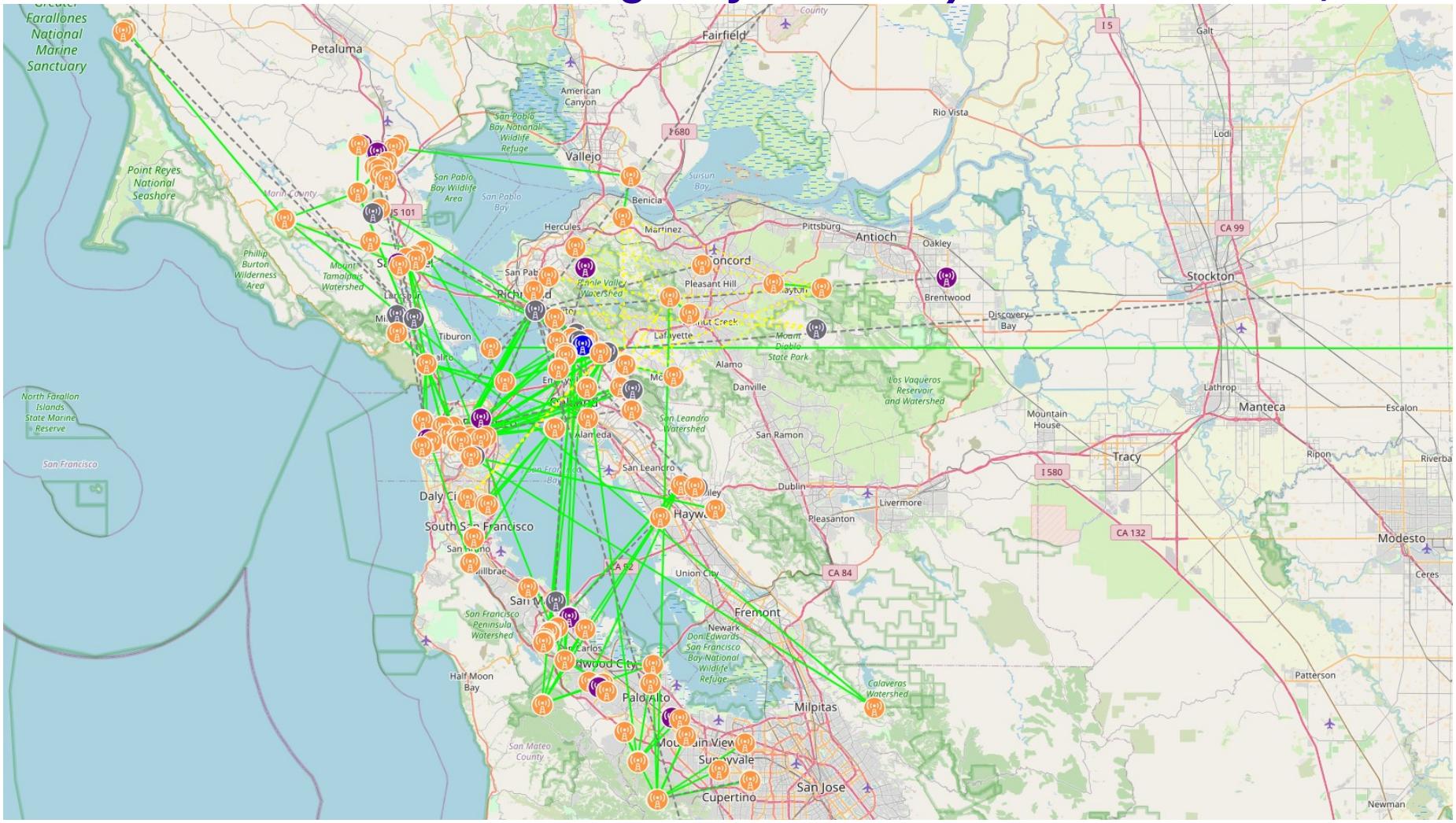
Network map – Yakima, WA



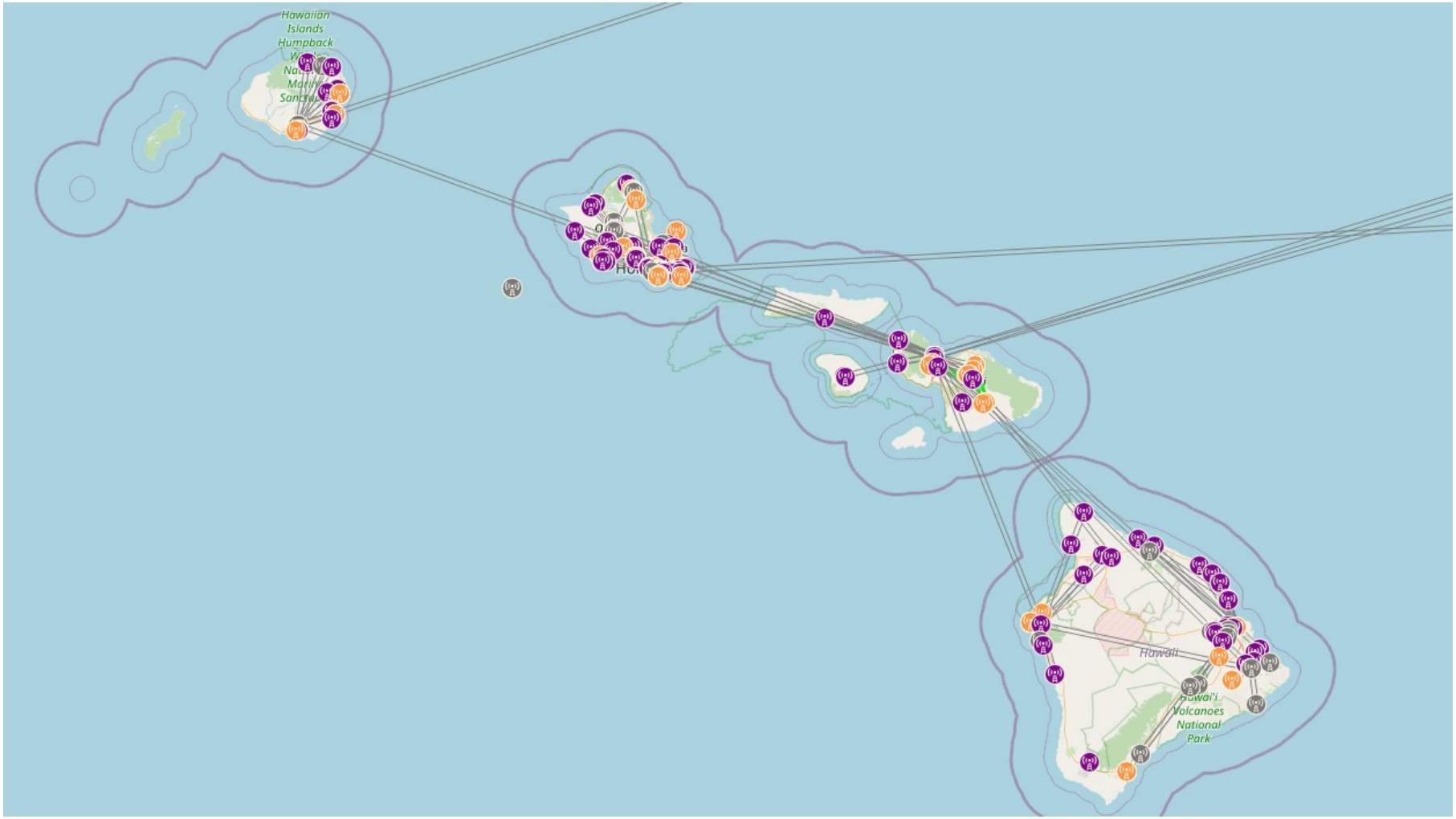
Network map – Salt Lake City, Utah



Network map – SFWEM
(San Francisco Wireless Emergency Network) - San Francisco, CA

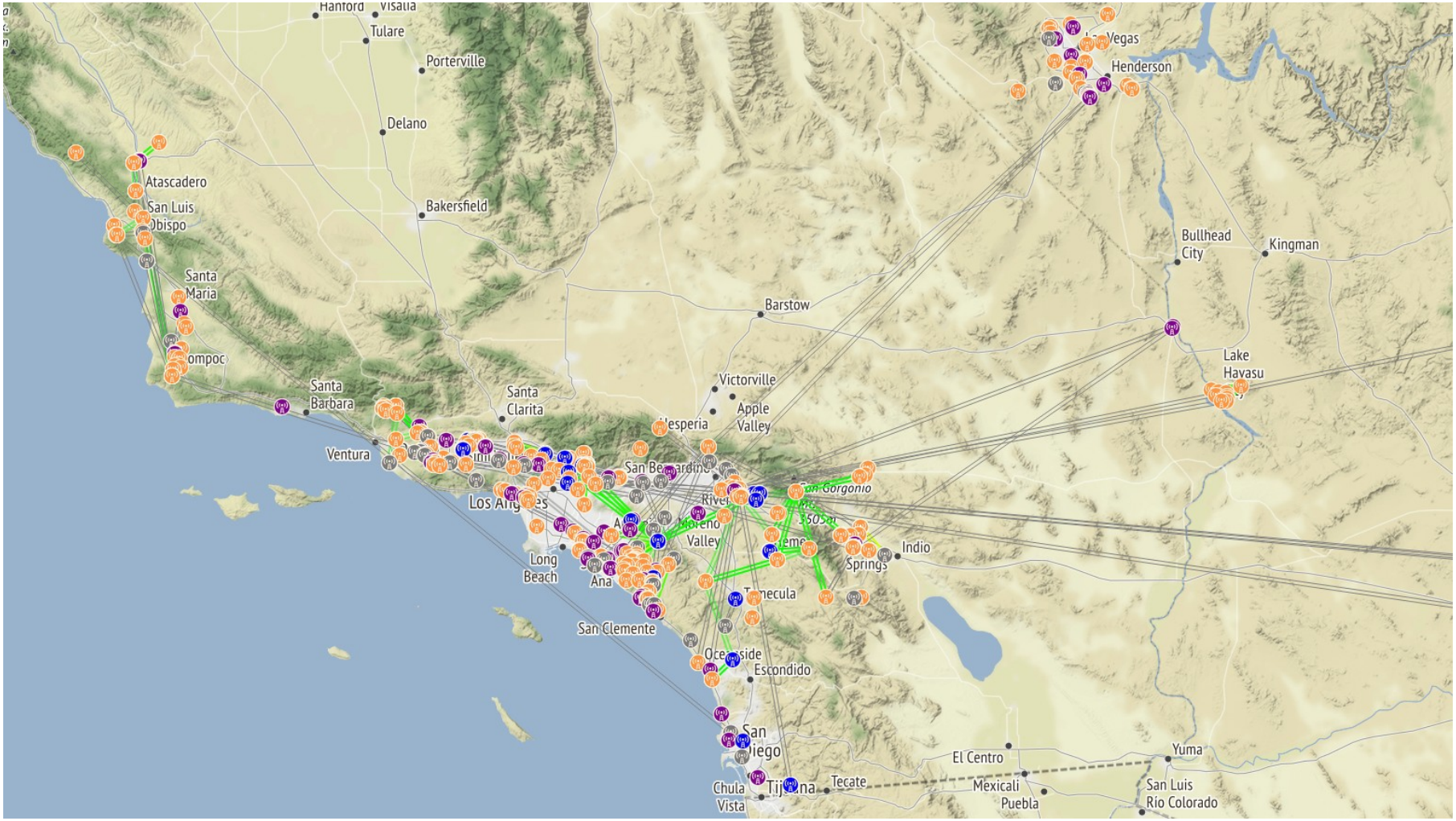


Network map – Hawaiian Islands

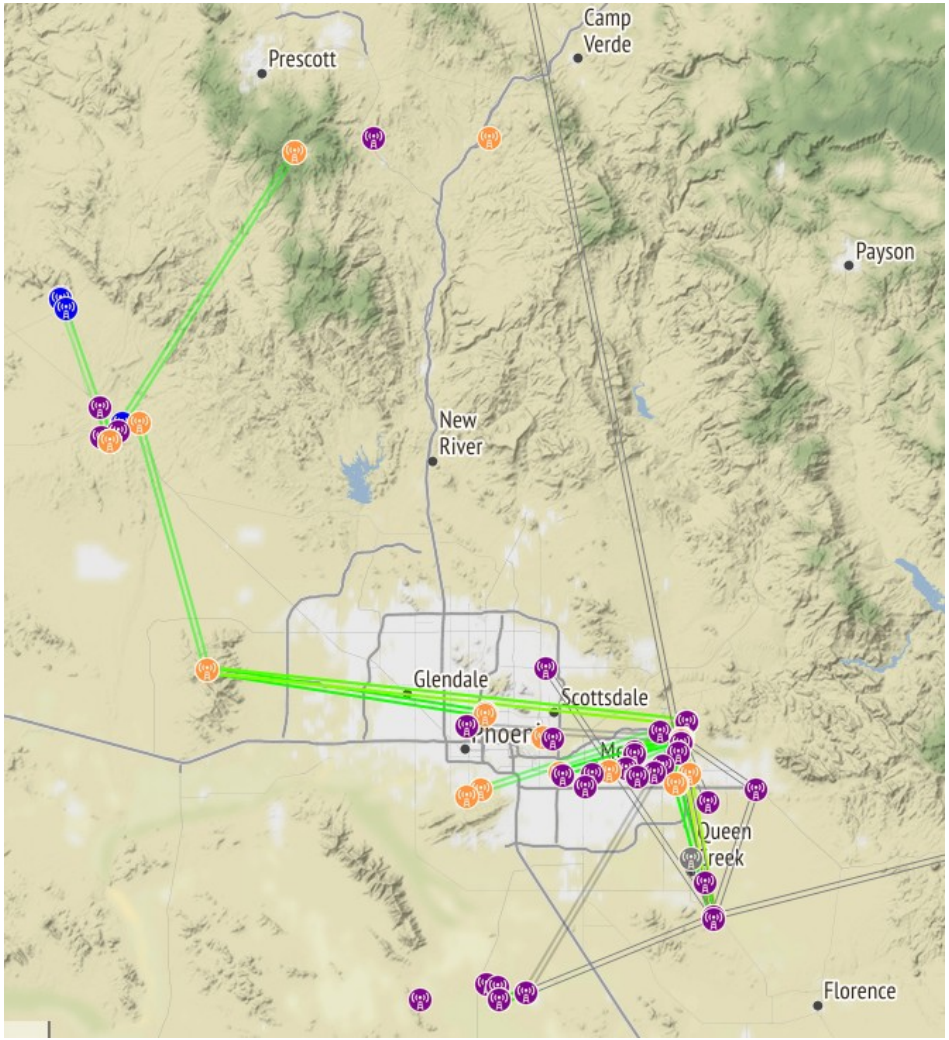


Network map – Southern California

About 425 nodes (hilltop & ground level) in area shown



Network map – Phoenix area



Equipment

What's out there??

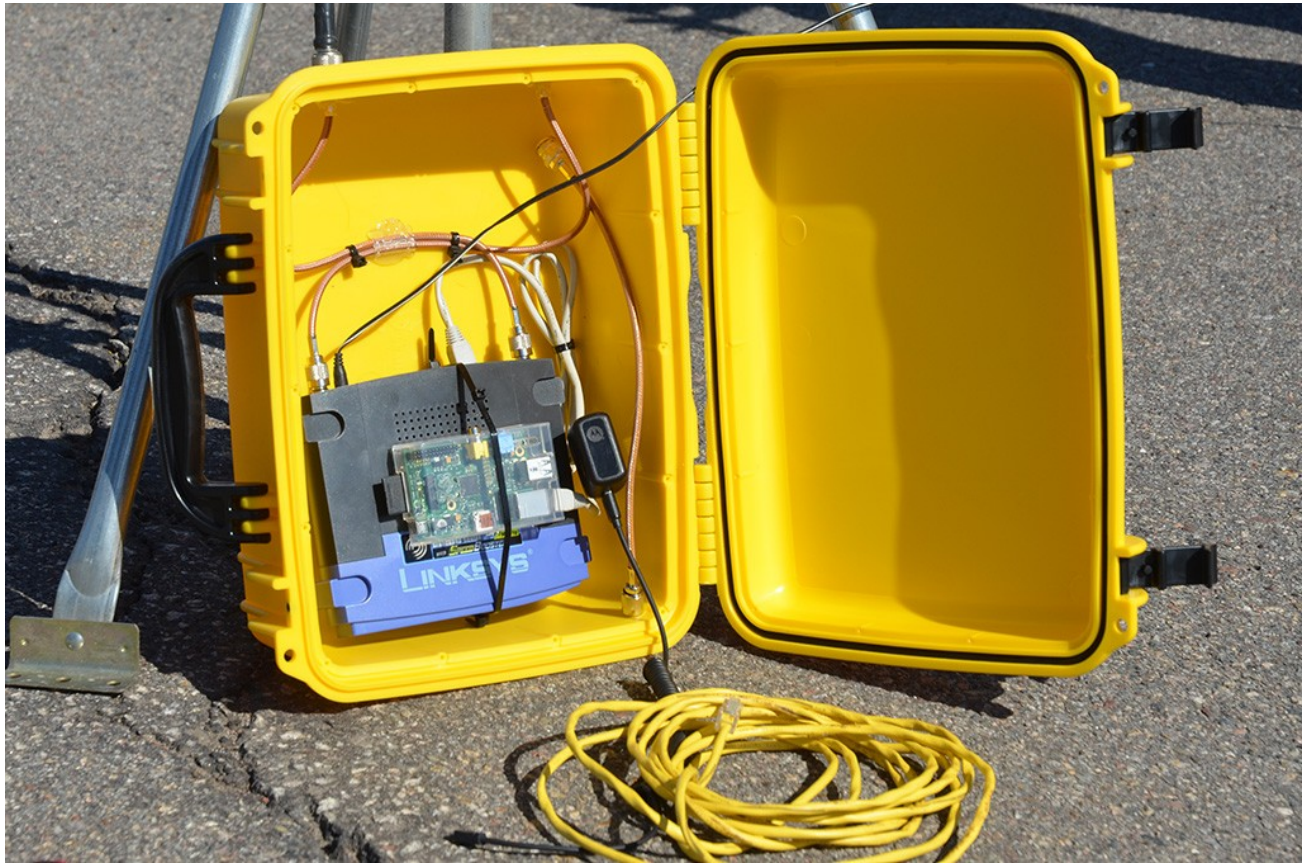
About Modern Access Points/AREDN Nodes

- Available for use in four amateur bands
  - Not expensive
  - Designed for outdoor use: weatherproof
  - Sophisticated software-defined transceivers (two for MIMO! - Multiple Input Multiple Output).
  - Built-in gain antennas in many models, one vertically-polarized, one horizontally polarized for two simultaneous data streams – on the same channel!
  - MIMO + 802.11n – much better performance than older gear
  - POE (Power Over Ethernet): only one cable required to node
  - *Use caution buying used equipment*
    - *Don't purchase if they only have 8 MB of flash or 32 MB of RAM; future versions of AREDN firmware may not fit in older 32 MB devices*
    - *Don't purchase if they're not MIMO:*
      - *poor performance compared to modern devices*
      - *don't interoperate optimally with MIMO gear (think water & oil);*
    - *The AREDN website (arednmesh.org) has a Support Platform Matrix that has flagged supported devices that are no longer recommended for new deployments*
  - *Don't buy 802.11ac devices yet; support may be available by ~~4Q22~~ ???*

Old School (ca 2012)

One wireless transceiver, only 60 mW.

Not MIMO, not 802.11n, only 16 MB of RAM, not weatherproofed



The next brand of access points supported by AREDN was Ubiquiti
The Ubiquiti Bullet
600 mW output

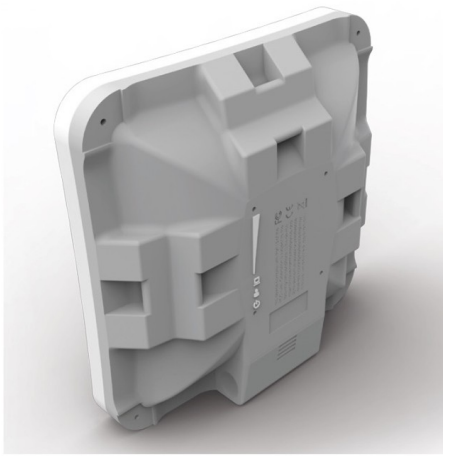
Ubiquiti Bullet – not MIMO, only 32 MB of RAM

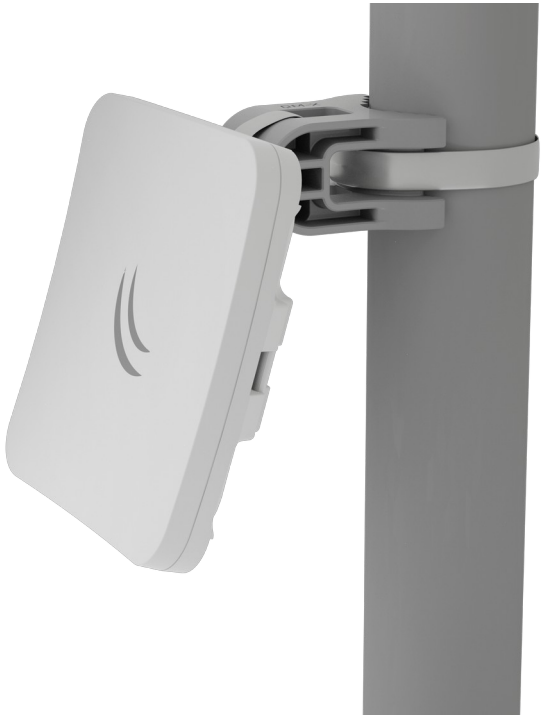
The next generation for the home QTH was the Ubiquiti Nanostation M2* & M5*

*No longer recommended (by me) for new purchases

Mikrotik SXTsq 2, 5

Short Haul - ~10-12 miles





Ubiquiti PowerBeam M5 300 (mm dia.), M5 400 & M5 620

Each has higher gain (but narrower beamwidth) than the previous version. Recommended.

(Starting to get scarce new; many now showing up on eBay after being replaced by WISPs – generally good buys)

Mikrotik LHG 5, LHG HP LHG 5 XL

Becoming very popular. Lighter weight than equivalent Ubiquiti – better for portable work

Mikrotik LDF (Light Dish Feed) 5

Inexpensive, 9 dBi gain.

- Mikrotik LDF 5 (5 GHz) installed at dish feedpoint using universal mount ($8 from Amazon) ~23 dBi gain
- Ideal for hams under an HOA, as satellite dishes are allowed!
- LDF 2 (2 GHz) now also supported by AREDN software

Mikrotik LDF 5

Installed in portable (foldable!) satellite TV dish – from K9CQB

TP-Link – less popular but work very well (all 64 MB devices)

- CPE 210, 220, WBS-210 - 2.4 GHZ
- CPE 510, WBS 510 - 5.8 GHz
  - Like Nanostations
- CPE 610 – dish for 5.8 GHz
  - No longer in production; available via eBay
  - Support for replacement (CPE710) approximately ~~4Q22~~ ???

GL.iNet Products

AR750 Creta (not Slate)

- 2.4 GHz & 5.8 GHz* MIMO
- Range: several hundred yards (no external antennas)
- Useful for Field Day logging or remote access on a network site.
- USB-powered
- Will run for a long time when plugged into a USB battery pack (for use as a relay site).

*WiFi only; mesh not supported

Other Network Station Requirements

- Shielded (per Ubiquiti) outdoor network cable. Could be unshielded if lightning isn't an issue in your area (IMO)
  - Pre-terminated lengths are available if you're uncomfortable terminating RJ45 cables
- Needs a dedicated computer for mesh network, because it's a standalone network with no connection to home network (but there's a way around that – see Mikrotik hAP AC Lite slides)
- Clear line of sight, because…

Line of Sight

"Microwaves can go ~~15~~ miles or through one tree"

~~25~~

35

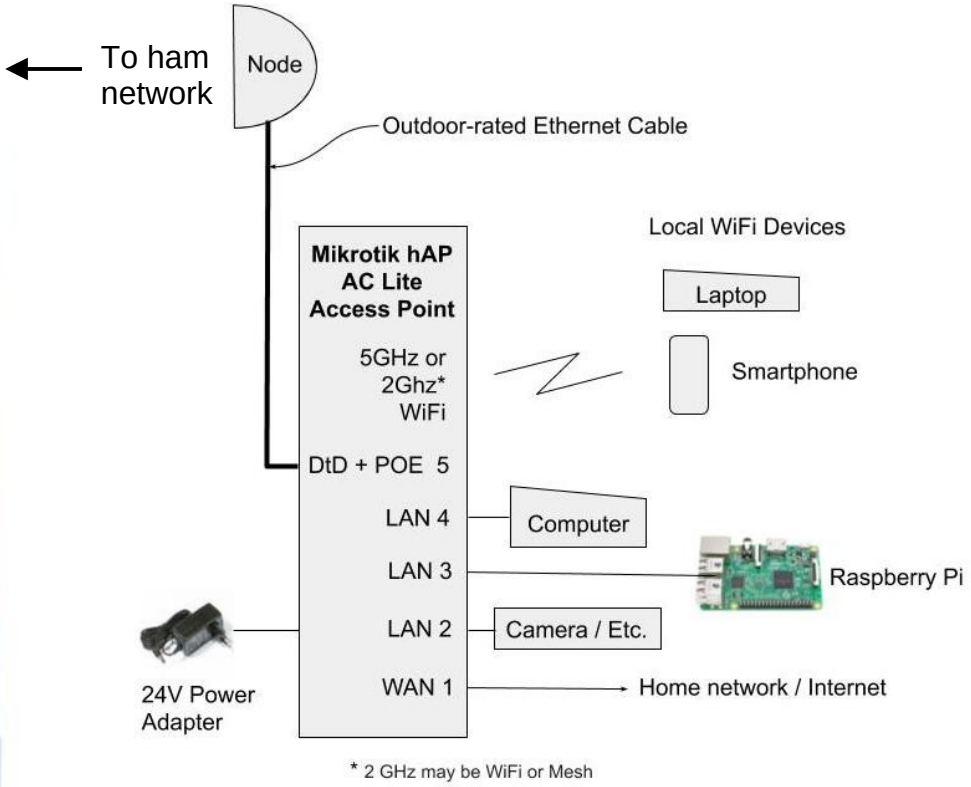
But two's company, tree's a crowd...

Mikrotik hAP AC Lite

The Swiss Army Knife of ham networking

A valuable addition to a ham shack network

A Mikrotik hAP Ac Lite running AREDN software integrated into your home network – recommended!



- Port 1 – Wired connection to home network
- Ports 2-4 – other devices on your ham network
- Port 5 provides POE power plus DtD (Device to Device) link for routing info to/from node – your link to the mesh network
- 2 & 5 GHz internal radios can be used as ham network node (2 GHz only), a wireless access point or a wireless access client.
- Wired this way, devices on ports 2-4 or connected via the internal wireless access point have access to both the hamnet and the internet.
- The AREDN software firewalls the hamnet off from your home network.

Home Installation example

2 GHz & 5 GHz Nanostations, (for redundancy)

Station is three miles from hilltop site

Home Installation example

Ubiquiti Nanostation & Mikrotik dish

Ethernet cable goes to Nanostation main port. Secondary port goes to Mikrotik dish, providing POE and network connectivity. Only one Ethernet cable up the mast is required!

Hilltop equipment – Ubiquiti 120 degree sector antenna with Rocket M5 5.8 GHz node attached on back

Small site Example - North Orange County, California

120 degree sector antennas & nodes for 2.4, 3 & 5 GHz

Medium Site Example – Chatsworth Peak, California

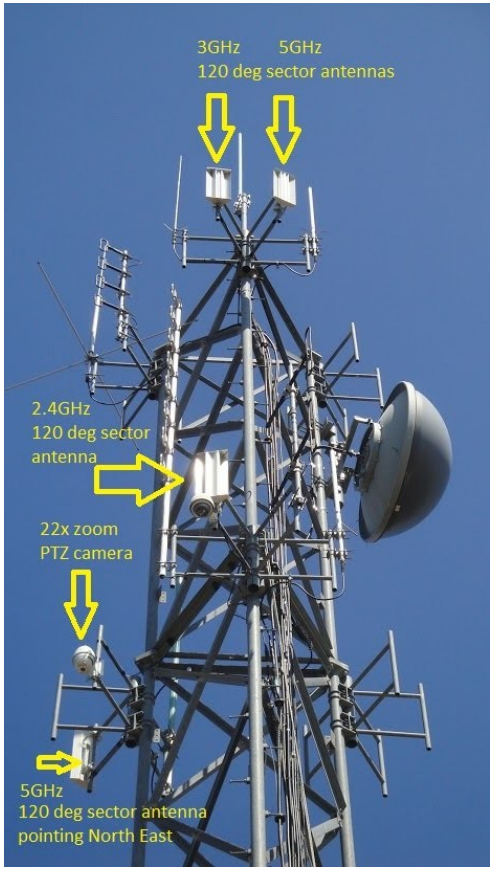
User access points on 2.4 & 5 GHz; dish for backbone link; PTZ camera

Another medium-sized site (post wind-storm)

(80% FM repeaters, 20% networking) Verdugo Peak, California

Large site (commercial) Pleasants Peak, California

Yellow-highlighted gear is for mesh network. 360 degree user access, backbone links (not shown) + PTZ camera



Ham Radio Allocations – 2.4 & 3 GHz

AREDN Offers 2 Non-Shared Channels on 2.4 GHz

2.4 GHz	Channel	-2	-1	0*	1	2	3	4	5	6
	Status	Ham Band			Shared Ham and ISM/WiFi Band					
	Freq	2.397	2.402	2.407	2.412	2.417	2.422	2.427	2.432	2.437

*Not available for use

Only one usable 10 MHz channel. Splatter from Part 15 limits usefulness

Channel	76	77	78	79	80	81	82	83	84	85	86	87
Status	Ham Band (continues indefinitely, pending future FCC action)											
Freq	3.380	3.385	3.390	3.395	3.400	3.405	3.410	3.415	3.420	3.425	3.430	3.435

	88	89	90	91	92	93	94	95	96	97	98	99
			Eliminated early 2022									
	3.440	3.445	3.450	3.455	3.460	3.465	3.470	3.475	3.480	3.485	3.490	3.495

Ham Radio Allocations – 5 GHz

52 Channels, 14 Non-Shared, on 5.8 GHz

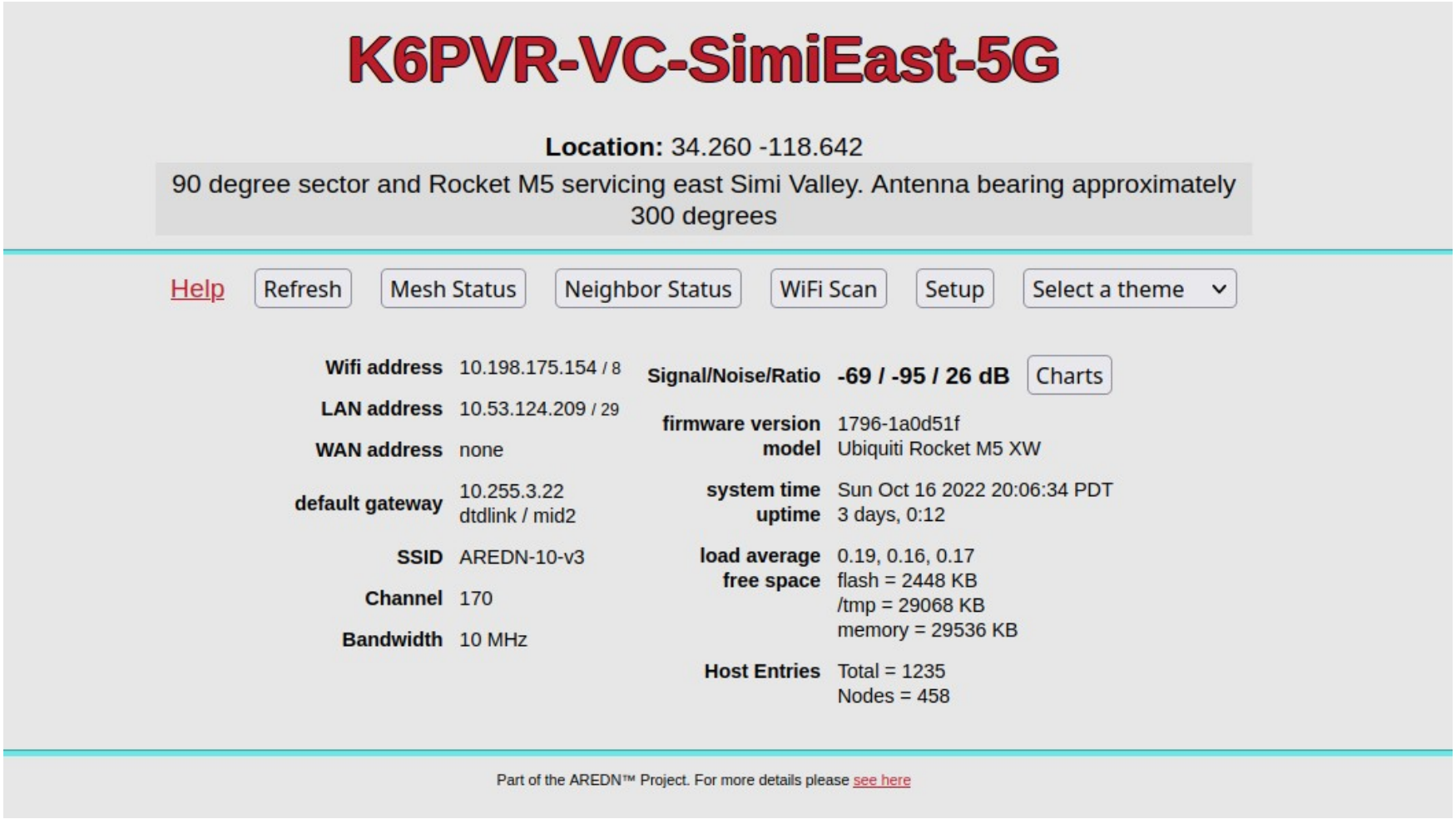
5.8 GHz														
	Channel	133	134	135	136	137	138	139	140	141	142	143	144	145
	Status	Ham Band shared with U-NII-2C/wifi/unlicensed												
	Freq	5.665	5.670	5.675	5.680	5.685	5.690	5.695	5.700	5.705	5.710	5.715	5.720	5.725
		146	147	148	149	150	151	152	153	154	155	156	157	158
		Ham Band shared with U-NII-3/wifi/unlicensed												
		5.730	5.735	5.740	5.745	5.750	5.755	5.760	5.765	5.770	5.775	5.780	5.785	5.790
		159	160	161	162	163	164	165	166	167	168	169	170	171
		Ham Band shared with U-NII-3/wifi/unlicensed											Ham Band	
		5.795	5.800	5.805	5.810	5.815	5.820	5.825	5.830	5.835	5.840	5.845	5.850	5.855
		172	173	174	175	176	177	178	179	180	181	182	183	184
		Ham Band												
		5.860	5.865	5.870	5.875	5.880	5.885	5.890	5.895	5.900	5.905	5.910	5.915	5.920

Refer to your local band plan for coordination; ★5825 to 5850 Shared under Part 15.247 with a limited number of WISP operators and may be encountered at tower sites

11/2020 – FCC removed DOT's primary allocation (they hadn't started using it). We kept our secondary allocation but the FCC will let Part 15 users expand into the entire band.

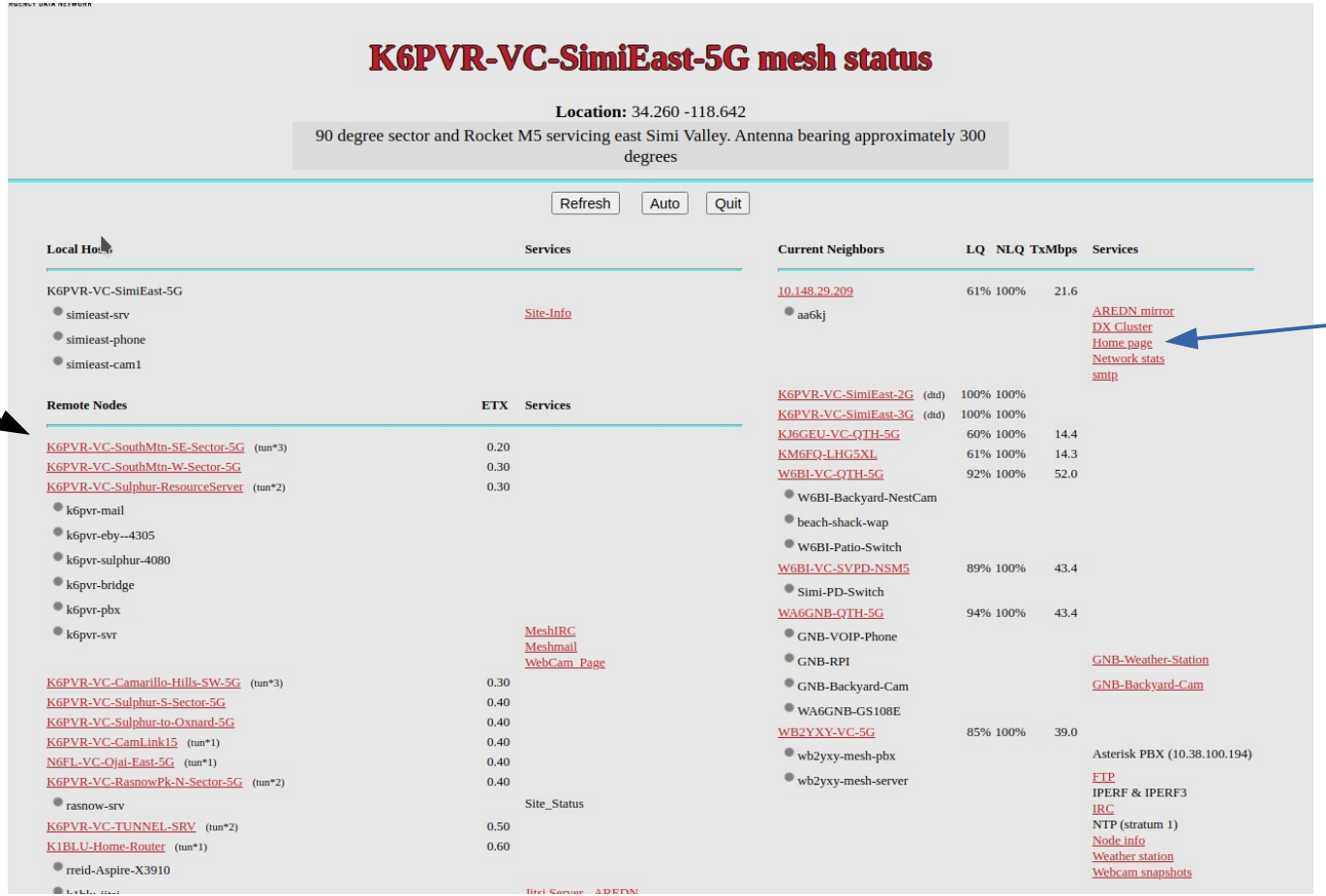
Over time, expect channel noise levels to rise. Plan on deploying higher gain devices than you currently need to future-proof installations (e.g., dishes instead of Nanostations).

The AREDN node interface (main screen)



The AREDN node interface – mesh status page

Remote nodes (more than one hop)



K6PVR-VC-SimiEast-5G mesh status

Location: 34.260 -118.642

90 degree sector and Rocket M5 servicing east Simi Valley. Antenna bearing approximately 300 degrees

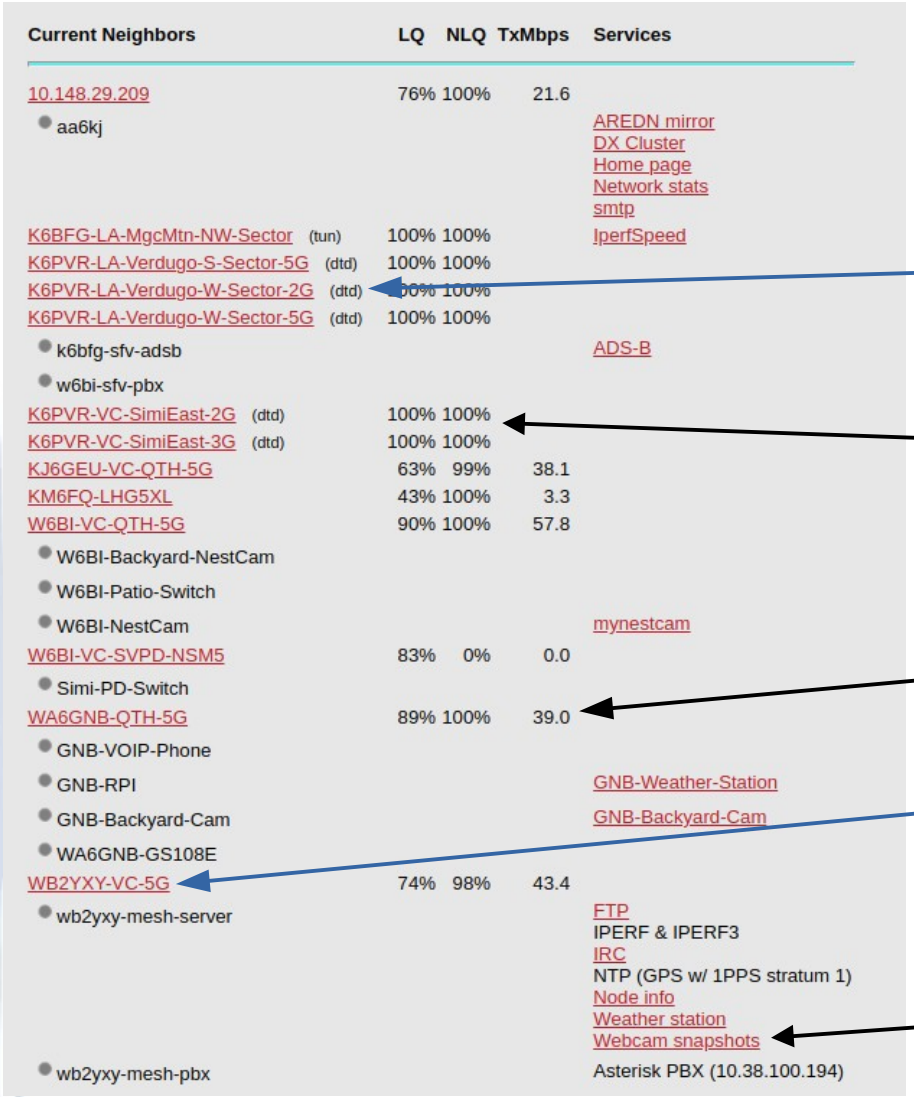
Refresh | Auto | Quit

Local Host	Services
K6PVR-VC-SimiEast-5G	
simieast-srv	Site-Info
simieast-phone	
simieast-cam1	

Remote Nodes	ETX	Services
K6PVR-VC-SouthMtn-SE-Sector-5G (tun*3)	0.20	
K6PVR-VC-SouthMtn-W-Sector-5G	0.30	
K6PVR-VC-Sulphur-ResourceServer (tun*2)	0.30	
k6pvr-mail		
k6pvr-eby--4305		
k6pvr-sulphur-4080		
k6pvr-bridge		
k6pvr-pbx		
k6pvr-svr		MeshIRC Meshmail WebCam_Page
K6PVR-VC-Camarillo-Hills-SW-5G (tun*3)	0.30	
K6PVR-VC-Sulphur-S-Sector-5G	0.40	
K6PVR-VC-Sulphur-to-Oxnard-5G	0.40	
K6PVR-VC-CamLink15 (tun*1)	0.40	
N6FL-VC-Ojai-East-5G (tun*1)	0.40	
K6PVR-VC-RasnowPk-N-Sector-5G (tun*2)	0.40	
rasnow-srv		Site_Status
K6PVR-VC-TUNNEL-SRV (tun*2)	0.50	
K1BLU-Home-Router (tun*1)	0.60	
rreid-Aspire-X3910		
k1blu-jitsi		Jitsi Server - AREDN

Current Neighbors	LQ	NLQ	TxMbps	Services
10.148.29.209	61%	100%	21.6	
aa6kj				AREDN mirror DX Cluster Home page Network stats smtp
K6PVR-VC-SimiEast-2G (dtd)	100%	100%		
K6PVR-VC-SimiEast-3G (dtd)	100%	100%		
KJ6GEU-VC-QTH-5G	60%	100%	14.4	
KM6FQ-LHG5XL	61%	100%	14.3	
W6BI-VC-QTH-5G	92%	100%	52.0	
W6BI-Backyard-NestCam				
beach-shack-wap				
W6BI-Patio-Switch				
W6BI-VC-SVPD-NSM5	89%	100%	43.4	
Simi-PD-Switch				
WA6GNB-QTH-5G	94%	100%	43.4	
GNB-VOIP-Phone				
GNB-RPI				GNB-Weather-Station
GNB-Backyard-Cam				GNB-Backyard-Cam
WA6GNB-GS108E				
WB2YXY-VC-5G	85%	100%	39.0	
wb2yxy-mesh-pbx				Asterisk PBX (10.38.100.194)
wb2yxy-mesh-server				FTP IPERF & IPERF3 IRC NTP (stratum 1) Node info Weather station Webcam snapshots

Local neighbors and the services they are providing



Current Neighbors	LQ	NLQ	TxMbps	Services
10.148.29.209	76%	100%	21.6	
aa6kj				AREDN mirror DX Cluster Home page Network stats smtp
K6BFG-LA-MgcMtn-NW-Sector (tun)	100%	100%		IperfSpeed
K6PVR-LA-Verdugo-S-Sector-5G (dtd)	100%	100%		
K6PVR-LA-Verdugo-W-Sector-2G (dtd)	100%	100%		
K6PVR-LA-Verdugo-W-Sector-5G (dtd)	100%	100%		
k6bfg-sfv-adsb				ADS-B
w6bi-sfv-pbx				
K6PVR-VC-SimiEast-2G (dtd)	100%	100%		
K6PVR-VC-SimiEast-3G (dtd)	100%	100%		
KJ6GEU-VC-QTH-5G	63%	99%	38.1	
KM6FQ-LHG5XL	43%	100%	3.3	
W6BI-VC-QTH-5G	90%	100%	57.8	
W6BI-Backyard-NestCam				
W6BI-Patio-Switch				
W6BI-NestCam				mynestcam
W6BI-VC-SVPD-NSM5	83%	0%	0.0	
Simi-PD-Switch				
WA6GNB-QTH-5G	89%	100%	39.0	
GNB-VOIP-Phone				
GNB-RPI				GNB-Weather-Station
GNB-Backyard-Cam				GNB-Backyard-Cam
WA6GNB-GS108E				
WB2YXY-VC-5G	74%	98%	43.4	
wb2yxy-mesh-server				FTP IPERF & IPERF3 IRC NTP (GPS w/ 1PPS stratum 1) Node info Weather station Webcam snapshots
wb2yxy-mesh-pbx				Asterisk PBX (10.38.100.194)

Right column: RF and Networked links

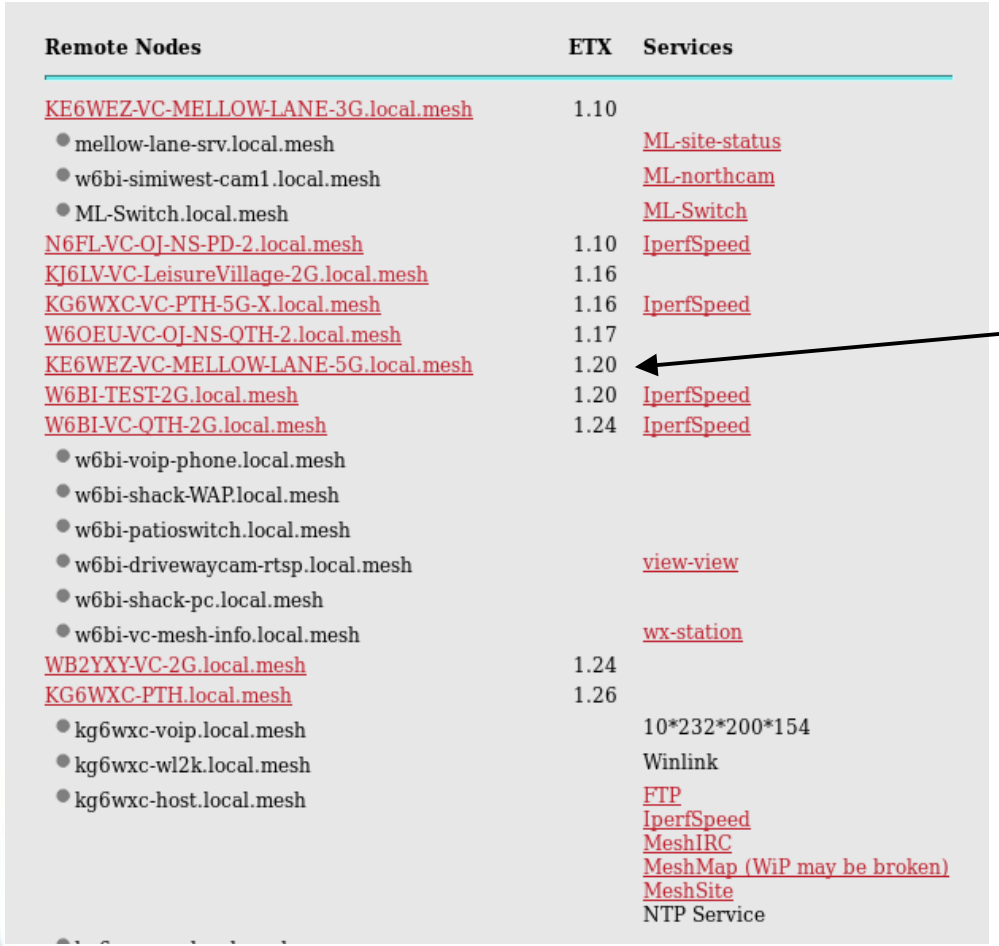
Local linked neighbors (not direct RF; DtD via Ethernet cable, or other)

LQ – Link Quality
NLQ – Neighbor Link Quality

Modulation rate times actual packet success rate

Local RF neighbors

Services provided by this node



Remote Nodes	ETX	Services
KE6WEZ-VC-MELLOW-LANE-3G.local.mesh	1.10	
• mellow-lane-srv.local.mesh		ML-site-status
• w6bi-simiwest-cam1.local.mesh		ML-northcam
• ML-Switch.local.mesh		ML-Switch
N6FL-VC-OJ-NS-PD-2.local.mesh	1.10	IperfSpeed
KJ6LV-VC-LeisureVillage-2G.local.mesh	1.16	
KG6WXC-VC-PTH-5G-X.local.mesh	1.16	IperfSpeed
W6OEU-VC-OJ-NS-QTH-2.local.mesh	1.17	
KE6WEZ-VC-MELLOW-LANE-5G.local.mesh	1.20	
W6BI-TEST-2G.local.mesh	1.20	IperfSpeed
W6BI-VC-QTH-2G.local.mesh	1.24	IperfSpeed
• w6bi-voip-phone.local.mesh		
• w6bi-shack-WAP.local.mesh		
• w6bi-patioswitch.local.mesh		
• w6bi-drivewaycam-rtsp.local.mesh		view-view
• w6bi-shack-pc.local.mesh		
• w6bi-vc-mesh-info.local.mesh		wx-station
WB2YXY-VC-2G.local.mesh	1.24	
KG6WXC-PTH.local.mesh	1.26	
• kg6wxc-voip.local.mesh		10*232*200*154
• kg6wxc-wl2k.local.mesh		Winlink
• kg6wxc-host.local.mesh		FTP IperfSpeed MeshIRC MeshMap (WiP may be broken) MeshSite NTP Service

Left column: Remote Nodes

ETX – Expected Transmission Count – the average number of packets transmitted to get one packet through. Lower is better.

~ < 8 OK for text

~ < 5 OK for voice

~ < 3 OK for video

YMMV!

The formula: ETX=1/(NLQ*LQ)

Per hop. End to end ETX is sum of the ETXes of all the hops.

Where to get AREDN Ham Network Info

- Amateur Radio Emergency Data Network (arednmesh.org)
  - List of supported products
  - Software downloads (production & nightly builds)
  - How-Tos
  - FAQs
  - Extensive, detailed documentation
  - Forums – more than 4,100 users
- Facebook page (unofficial) – more than 1,900 users; fairly active
- AREDN channel on YouTube
  - * Beware of older HSMM or AREDN YouTube videos; they can be way out of date.

Coverage calculators (can two sites ‘see’ each other?)

- Heywhatsthat.com – easy to use
- https://airlink.ui.com/#/ptp - easy to moderate
- Radiofresnel.com – moderate
- Radio Mobile - complex
    - http://www.ve2dbe.com/english1.html

How do I Get Started?

- Ask around your club; ask around repeaters and/or mailing lists
- Get a link going (may require some tree trimming)
- Or tunnel someplace, if no RF link
- Make friends with repeater owners! (Especially if site is line of sight to you) Point out the advantages of being networked :-)
- Join the AREDN forums and/or any local mailing lists. Read!

Important notes!

- Do **not** stand in front of the radio for extended periods of time when it's powered on. NEVER look into the focus of the radio when it's powered on. The small dishes have 80 - 100 watts of ERP at 5.8 GHz!
- The Mikrotik Basebox 2 has 30 dBm of power output. When fed to a Mikrotik 30dBi gain dish that's **1 KW** of ERP. **Use caution!**