

Using AREDN Software to Create a Ham Radio IP Network

Updated 10/16/2022 – Vers. 5.0

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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

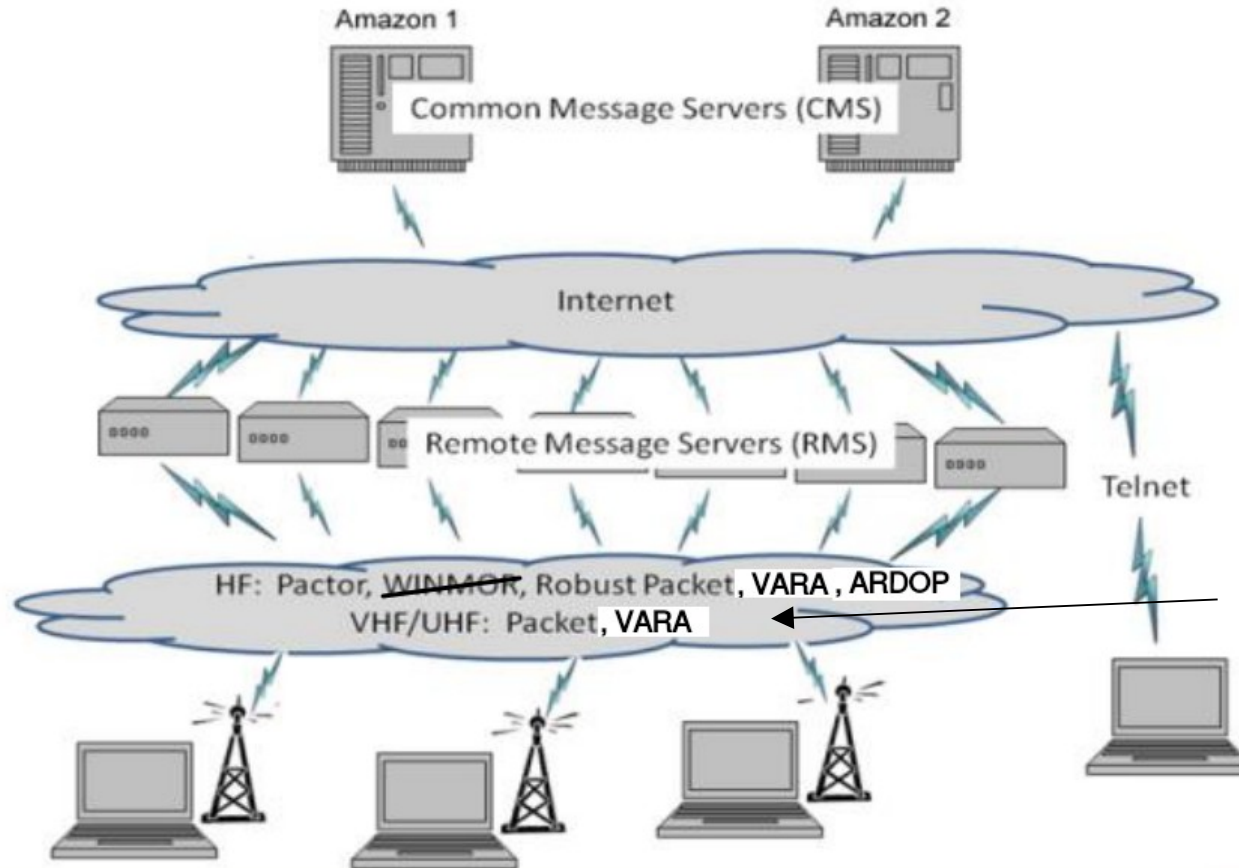
- AX.25 Packet Radio
- APRS
- VARA/FM
- AREDN network (recently added)
 - ◆ much faster, no digipeating required
- Has a large set of standardized messaging templates. (e.g. ICS, USGS, FEMA)

Winlink Architecture (Conventional Mode)

- CMS

- RMS
(gateway)

- Client
(you)



Ham networking
goes here

Winlink Express Client

Winlink Express 1.5.35.0 - W6BI

W6BI Settings Message Attachments Move To: Saved Items Delete Open Session: Telnet Post Office Logs Help

In Telnet Post Office session.

System Folders	Date/Time	Message ID	Size	Source	Sender	Recipient	Subject
Inbox (0 unread)	2021/03/10 18...	QJE5JUWYO...	176	KE6MLF	KE6MLF	W6BI	Howdy
Read Items (0)	2021/03/10 00...	LNTFUR6YP...	434	AJ7C	AJ7C	W6BI	Re: CW ID?
Outbox (0)	2021/03/09 22...	BWVVIS1AY...	269	SMTP	SMTP:winlink...	W6BI	Your Winlink Checkin Was Received
Sent Items (51)	2021/03/07 23...	QQ8WWM8P...	436	AJ7C	AJ7C	W6BI	Re: Other bands?
Saved Items (0)	2021/03/07 19...	S33XEVUJ02...	920	AJ7C	AJ7C	W6BI	Re: What are these?
Deleted Items (2)	2021/03/06 04...	PGRLPLGF6...	727	AJ7C	AJ7C	W6BI	Re: What are these?
Drafts (0)	2021/03/04 22...	5JCNR37ET...	464	AJ7C	AJ7C	W6BI	Re: More HF coverage
Personal Folders	2021/03/04 22...	111BSVR6ZF1	469	AJ7C	AJ7C	W6BI	Re: What are these?
Global Folders	2021/03/02 22...	OSIR2S1WB...	268	SMTP	SMTP:winlink...	W6BI	Your Winlink Checkin Was Received
Contacts	2021/02/28 20...	FUBFTPVZR...	1045	AJ7C	AJ7C	W6BI	Re: First HF connection!

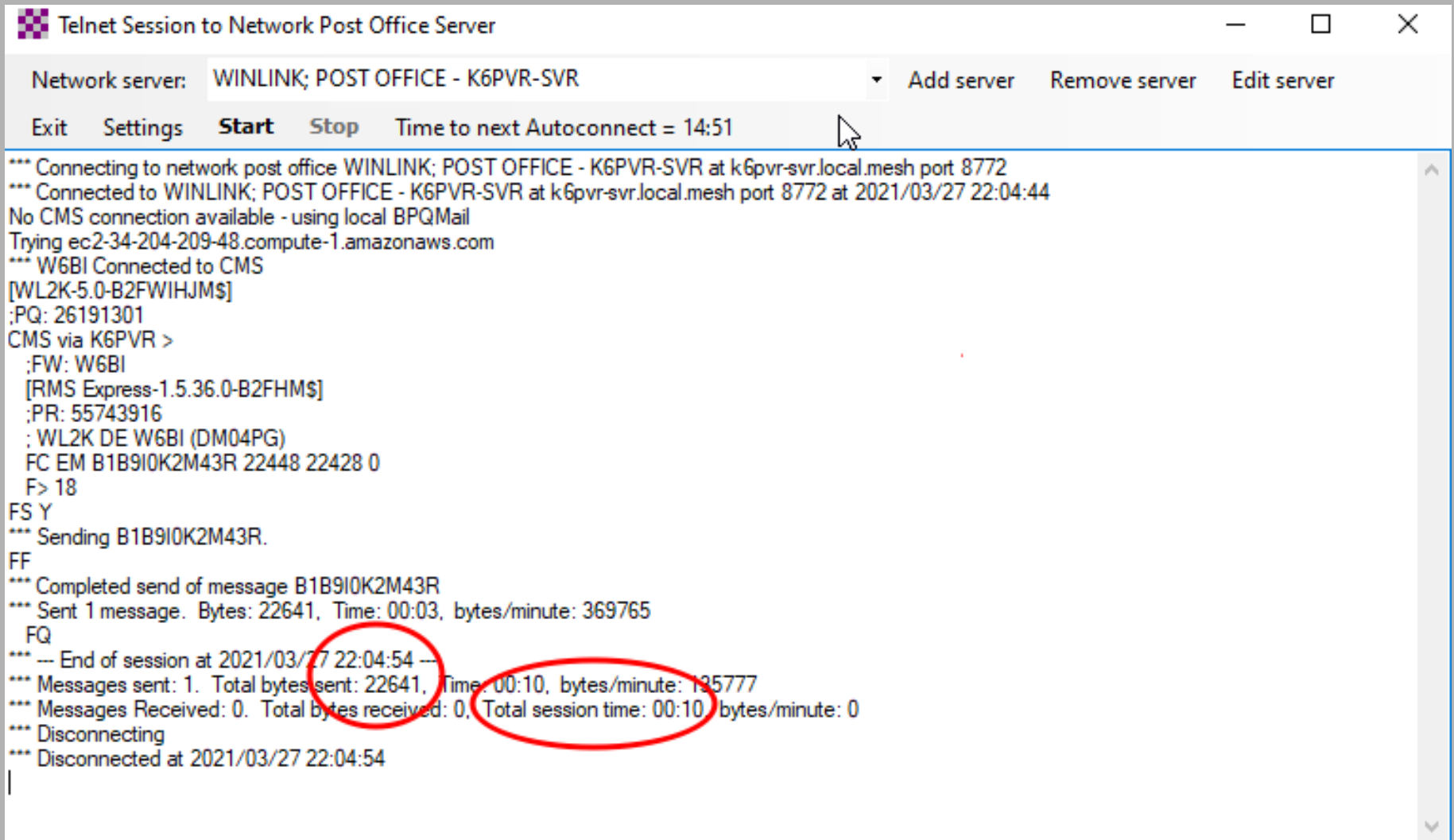
Message ID: QJE5JUWYO609
Date: 2021/03/10 18:42
From: KE6MLF
To: W6BI
Source: KE6MLF|
Downloaded-from: Post-office:WINLINK - AI6BX-MESH-PC
Subject: Howdy

Is this working?

[Message receipt requested]

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!



Telnet Session to Network Post Office Server

Network server: WINLINK; POST OFFICE - K6PVR-SVR Add server Remove server Edit server

Exit Settings **Start** Stop Time to next Autoconnect = 14:51

```
*** Connecting to network post office WINLINK; POST OFFICE - K6PVR-SVR at k6pvr-svr.local.mesh port 8772
*** Connected to WINLINK; POST OFFICE - K6PVR-SVR at k6pvr-svr.local.mesh port 8772 at 2021/03/27 22:04:44
No CMS connection available - using local BPQMail
Trying ec2-34-204-209-48.compute-1.amazonaws.com
*** W6BI Connected to CMS
[WL2K-5.0-B2FWIHJM$]
:PQ: 26191301
CMS via K6PVR >
:FW: W6BI
[RMS Express-1.5.36.0-B2FHM$]
:PR: 55743916
: WL2K DE W6BI (DM04PG)
FC EM B1B9I0K2M43R 22448 22428 0
F> 18
FS Y
*** Sending B1B9I0K2M43R.
FF
*** Completed send of message B1B9I0K2M43R
*** Sent 1 message. Bytes: 22641, Time: 00:03, bytes/minute: 369765
FQ
*** --- End of session at 2021/03/27 22:04:54 ---
*** Messages sent: 1. Total bytes sent: 22641, Time: 00:10, bytes/minute: 135777
*** Messages Received: 0. Total bytes received: 0, Total session time: 00:10, bytes/minute: 0
*** Disconnecting
*** Disconnected at 2021/03/27 22:04:54
```

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

CHAT FILES STATUS LOGOUT

Mesh Chat v1.0

Zone: LWMeshChat Call Sign: K7FPV Node: laytonwestdistrict Updated: 14 seconds ago

File Sharing

Shows sync status with other nodes

Zone

Send a Message

New Message

Enter message here

Channel: Everything SEND

Enter new messages here

Search Messages

Mesh Chat Users 1

Call Sign	Node	Last Seen
K7FPV	laytonwestdistrict	10/11/16 10:51 AM

Users logged in

Messages

Search: Enter search Channel: Everything

Which channel to send the message to

Time	Message	Call Sign	Channel	Node
10/11/16 10:50 AM	This is meshchat. It is a messaging and file sharing app for AREDN mesh networks.	K7FPV		
	It is fully redundant and decentralized. It works with spotty links and requires very little bandwidth.			

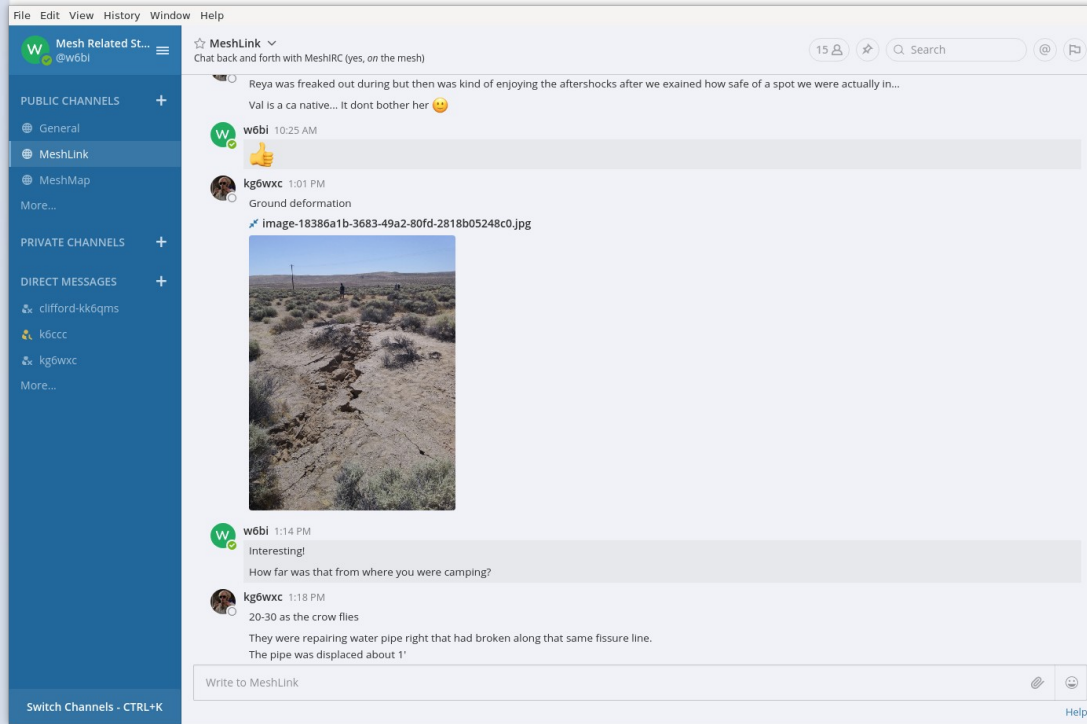
Messages in the db

Filter messages by channel

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

The screenshot shows the TeamTalk v. 5.4 interface. The window title is "TeamTalk v. 5.4". The menu bar includes "Client", "Me", "Users", "Channels", "Server", and "Help". Below the menu bar is a toolbar with icons for various functions. The main interface is divided into two main sections: a user list on the left and a chat window on the right.

User List: The user list is titled "K6PVR Ventura County Teamtalk (14)". It contains the following users and their status (indicated by checkmarks in columns):

User	Column 1	Column 2	Column 3	Column 4
Brian - AE7WY	✓	✓	✓	✓
Dale WA6MZW Cathedral City	✓	✓	✓	✓
Dave km6fq	✓	✓	✓	✓
Endaf - N6UTC Long Beach.	✓	✓	✓	✓
eric - kg6wxc - oxnard	✓	✓	✓	✓
Ian AJ6GZ - Redlands	✓	✓	✓	✓
Jim - K6CCC	✓	✓	✓	✓
K3CAQ Andy Thousand Oaks	✓	✓	✓	✓
K6CCC iPhone	✓	✓	✓	✓
Kevin - AJ7C - Culver City	✓	✓	✓	✓
KM6FQ Dave	✓	✓	✓	✓
Orv - W6BI - Simi Valley	✓	✓	✓	✓
Ryan - K1BLU - Lakewood	✓	✓	✓	✓
Steve - K6CRW	✓	✓	✓	✓
Aux Channel 1 (0)				
Aux Channel 2 (0)				

Chat Window: The chat window is titled "Chat" and shows a log of messages. The messages are as follows:

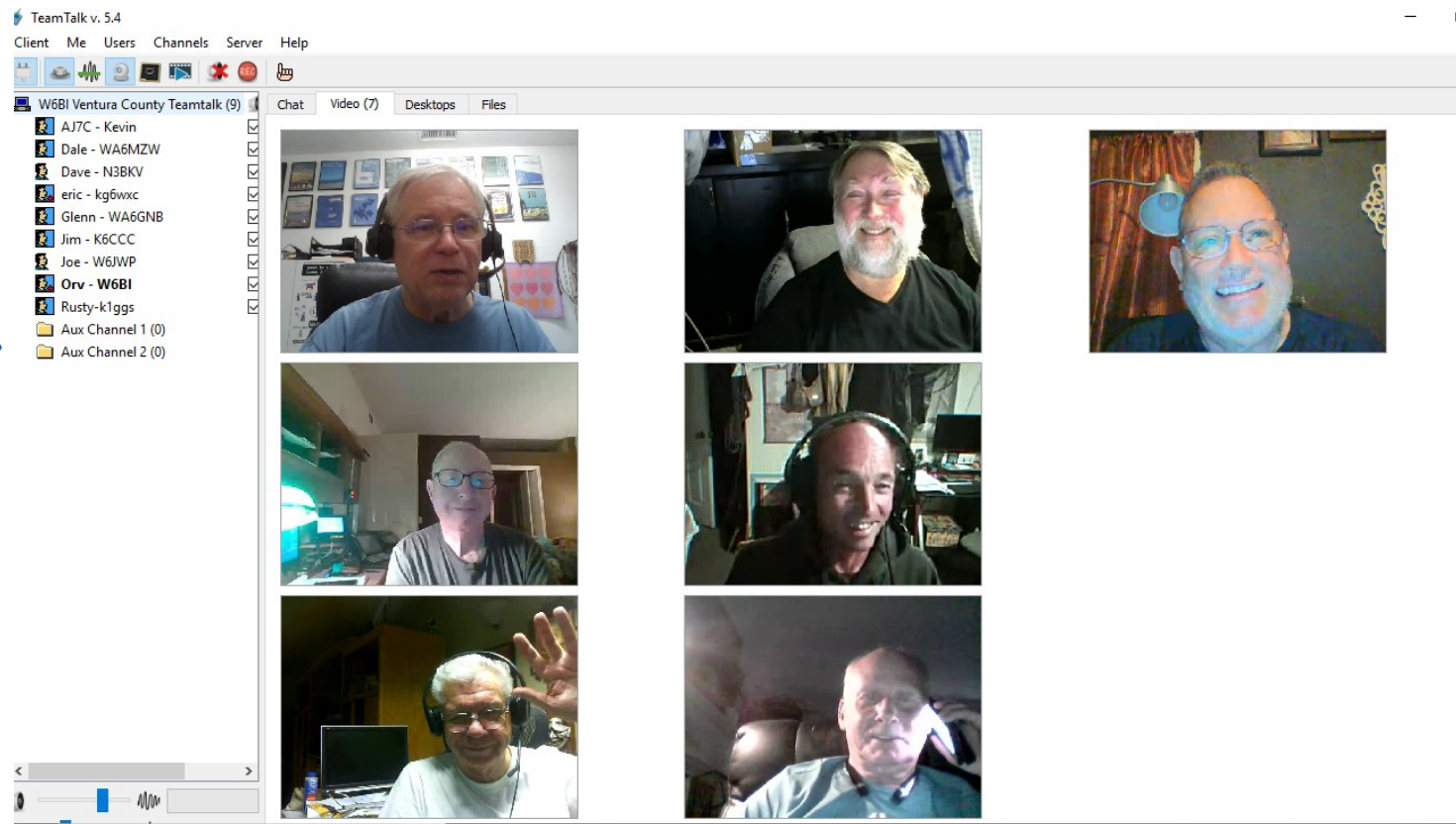
2020-04-15T20:04:05 *Ryan - K1BLU - Lakewood left channel
2020-04-15T20:04:11 *Ryan - K1BLU - Lakewood joined channel
2020-04-15T20:04:18 *Endaf - N6UTC Long Beach. joined channel
2020-04-15T20:06:26 <Endaf - N6UTC Long Beach. > no im here
2020-04-15T20:07:49 *K3CAQ Andy Thousand Oaks joined channel
2020-04-15T20:07:58 *Endaf - N6UTC Long Beach. left channel
2020-04-15T20:08:43 *K3CAQ Andy Thousand Oaks left channel
2020-04-15T20:09:17 *K3CAQ Andy Thousand Oaks joined channel
2020-04-15T20:13:29 *Dale WA6MZW Cathedral City joined channel
2020-04-15T20:14:45 *Endaf - N6UTC Long Beach. joined channel
2020-04-15T20:15:11 *Endaf - N6UTC Long Beach. left channel
2020-04-15T20:18:11 *Endaf - N6UTC Long Beach. joined channel
2020-04-15T20:19:47 *Endaf - N6UTC Long Beach. left channel
2020-04-15T20:20:16 *Endaf - N6UTC Long Beach. joined channel
2020-04-15T20:24:12 *Dave km6fq joined channel
2020-04-15T20:25:56 *Dave km6fq left channel
2020-04-15T20:26:14 *Dave km6fq joined channel
2020-04-15T20:26:30 *Kevin - AJ7C - Culver City joined channel
2020-04-15T20:26:32 *Dave km6fq left channel
2020-04-15T20:26:37 *K3CAQ Andy Thousand Oaks left channel
2020-04-15T20:26:45 *Dave km6fq joined channel
2020-04-15T20:27:41 *eric - kg6wxc - oxnard joined channel
2020-04-15T20:27:41 *eric - kg6wxc - oxnard left channel
2020-04-15T20:28:12 *eric - kg6wxc - oxnard joined channel
2020-04-15T20:28:37 <eric - kg6wxc - oxnard> me 2, client is junk now.
2020-04-15T20:29:06 *K3CAQ Andy Thousand Oaks joined channel
2020-04-15T20:29:24 <Brian - AE7WY> <rtsp://AE7WY-Cam-Clark-WY.local.mesh:554/s2>

The chat window also has tabs for "Video", "Desktops", and "Files". At the bottom of the chat window is a "Send" button. Below the chat window is a microphone icon and a volume slider. At the bottom left of the interface, it shows "RX: 0.00KB TX: 0.00KB". At the bottom right, there is a "Push To Talk: Alt" button.

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)

 **EtherPad** Share this URL: <http://etherpad.com/jeresig-demo>  New pad

9 Yo

10 Hello?

11

12 A hoy hoy!

13

14 Neat! It seems like it's going in real-time.

15

16 Yes, it is! (AppJet has a scalable implementation of comet).

17

18 Nice. That's certainly something that's always a pain to try and get right.

19

20 Yeah, and we went to great pains to make sure it works on IE6 and stuff.

21

22 Awesome. So this is all part of that .jar, then?

23

24 Not released yet. The .jar lets you run apps that currently can run on appjet.com. Just 1-pagers basically.

25

26 EtherPad is the poster child for "project barmitzvah" -- wehre AppJet comes of age :). We'll release the new version of AppJet for all developers, open source, shortly afterwards.

27

28 Nice. So that big release is also happening next Wed.? (not necessarily the Open Source release).

29

30 That's actually going to take a littl bit of time. Next wednesday is just EtherPad and the announcement of the new platform coming. The new platform (not sure what to call it yet, maybe JavaScript On Jets (I own javascriptonjets.{com,net,org} :)))

31

32 Ha, nice. Ok, so a three-stage release - Etherpad, then platform, then open source platform.

33

34 Probably:

35 1. etherpad (next wed)

36 2. platform + open source to host yourself (a .jar basically)

37 3. ability to host any app on our servers, utility model

38

hide »

Connected Users

- John Resig [edit name/color](#)
24.61.14.106/Firefox3.0.3
- aaron
64.81.66.253/Firefox3.0.3
- Aaron (laptop)
64.81.66.114/Firefox3.0.3
- jd
64.81.66.219/Safari3.1.2

[invite more people...](#)

Saved Revisions

[Save Now](#)

[Revision 1](#) *saved 5 hours ago by John Resig (24.61.14.106)*
[view](#) | [restore](#)

Options

- Highlight who typed what.
- Wrap long lines.
- Show line numbers.
- Use full window width & height.
- Highlight JavaScript syntax.

Feedback

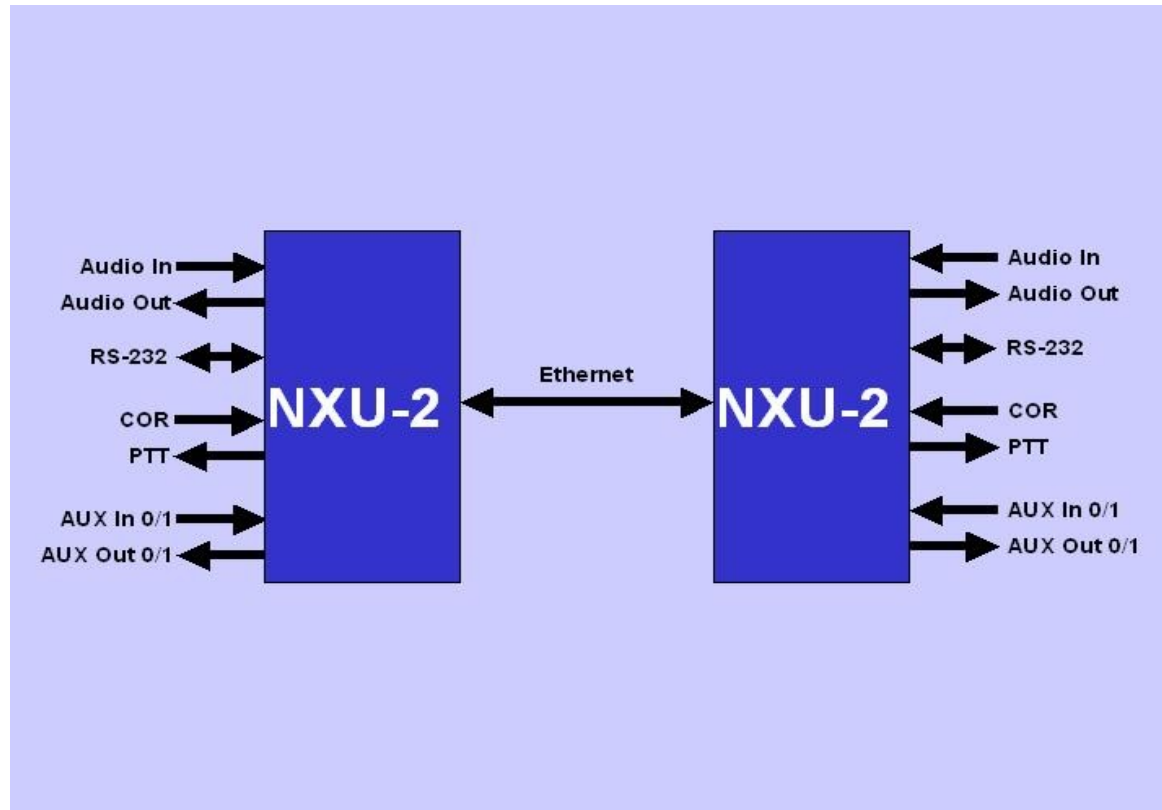
Powered by [AppJet](#) →

NextCloud – a drop box

The screenshot displays the NextCloud web interface. The top navigation bar is blue and contains the NextCloud logo, a 'Files' dropdown menu, a search icon, a home icon, and the user name 'admin'. The left sidebar shows navigation options: 'All files', 'Recent', 'Favorites', 'Shared with you', 'Shared with others', 'Shared by link', and 'Tags'. The main content area shows the 'backups' folder. The breadcrumb path is 'home > backups'. Below the breadcrumb is a table of files and folders. The table has columns for 'Name', 'Size', and 'Modified'. Each row includes a folder icon, the file name, a share icon, a three-dot menu icon, the size, and the modification time. At the bottom of the table, a summary row indicates '1 folder and 11 files' and a total size of '96.3 MB'.

Name	Size	Modified
games	589 KB	38 minutes ago
baptistewicht@gmail.com-takeout.zip	1.2 MB	3 years ago
budget_data_bak.tar.bz2	10 KB	2 years ago
budget_data_clean.tar.bz2	30 KB	2 years ago
budget_data_safe.tar.bz2	40 KB	2 years ago
google-docs-backup.zip	2.4 MB	3 years ago
old_backup.tar.bz2	17 MB	2 years ago
save_gentoo.tar.bz2	7.4 MB	2 years ago
save_gentoo_last.tar.bz2	1.1 MB	2 years ago
Sharepoint.tar.bz2	17.8 MB	2 years ago
task_data.tar.bz2	320 KB	2 years ago
windows_backup.tar.bz2	48.5 MB	2 years ago
1 folder and 11 files		96.3 MB

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

North-Central Simi Valley, Ventura County, CA
Monthly Reports:

03/10/2021 11:10:00 AM
Yearly Reports:

Current Conditions

Outside Temperature **46.2°F**
 Heat Index **44.5°F**
 Wind Chill **46.2°F**
 Dew Point **42.1°F**
 Humidity **85%**
 Barometer **30.006 inHg (0.014)**
 Wind **0 mph N/A (N/A)**
 Rain Rate **0.03 in/h**
 Rain Today **0.29 in**
 Inside Temperature **70.0°F**

Celestial

Sunrise **06:11:07 AM**
 Sunset **05:59:07 PM**
 Moon Phase **Waning crescent**
10%

High/Low

Today
 Outside Temperature **50.9 °F**
45.0
 Heat Index **49.3 °F**
 Wind Chill **41.3 °F**
 Dew Point **45.4 °F**
35.1
 Humidity **93 %**
68
 Barometer **30.056 inHg**
29.964
 Rain **0.29 in**
 Rain Rate **0.20 in/h**
 Wind Max **20 mph**
311 °
 Wind Average **2 mph**
 Wind RMS **3 mph**
 Vector Average **2 mph**
 Average Direction **300 °**
 Inside Temperature **70.5 °F**
68.2

About this weather station

Hardware **Ultimeter 2100**
 Latitude **34° 17.40' N**

History: Day Week Month Year

Barometer

Outside Temperature Dew Point

Wind Chill Heat Index

Humidity

Wind Speed Gust Speed

Wind Direction

Wind Vector

Rain (hourly total)

Inside Temperature

Weewx gone wild - highly-customized

Outside					Inside	
UV Index: 7	Temp	Humidity	Pressure	Wind	Temp	Humid
THI 79.8°F	Now 79.8°F	89%	29.77 -0.04	1 mph (SSE)	Now 77.7°F	51%
Dew Pt. 76.3°F	Max 87.4°F	96%	29.86	17 mph Gust	Max 78.2°F	52%
Wind Chill 79.8°F	Min 74.1°F	72%	29.77	2.7 10 min. avg.	Min 77.0°F	49%

Rain	
Rate	0.10 in/hr
Daily	0.11 in
24 hr	0.90 in
Monthly	4.11 in
Yearly	37.64 in

Hunters	
Moon Image Waning crescent (7% full)	

Net & Den's Fabulous Weather Station V4.1	
10/26/2019 03:24:00 PM	
Sunrise: 07:35:54 AM	Sunset: 06:51:32 PM
Latitude: 27° 07.91' N	
Longitude: 082° 26.09' W	
Altitude: 12 feet	
Weewx uptime: 47 days, 8 hours, 10 minutes	
Server uptime: 47 days, 8 hours, 29 minutes	
weewx v3.7.1 About	

Current Original Week Month Year -Select month-
-Select year-

Right click image (if hand pointer) for a BIGGER view (WIP)!

Nokomis, FL 7-Day Forecast
Issued 10:29 AM EDT Sat Oct 26 2019 [Click for more details](#)
[WeatherForYou.com](#)

Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
Chance Of Showers: 60%	Chance Of Showers: 40%	Chance Of Showers: 50%	Chance Of Showers: 40%	Chance Of Showers: 30%	Chance Of Showers: 20%	Chance Of Showers: 20%
89°F / 75°F	89°F / 75°F	89°F / 75°F	89°F / 75°F	89°F / 71°F	89°F / 71°F	89°F / 71°F

Location	Time	Water Temperature	Wave Height	Wave Period	Wave Direction
venf1 Venice Pier	October 26, 2019 1:00 pm EST	82.4°F (28.0°C)	4.3 ft	5 sec	SSE (168°)
42098 Egmont Channel	October 26, 2019 1:00 pm CST		4.6 ft	5 sec	SSE (168°)
42099 Offshore St. Pete	October 26, 2019 1:00 pm CST		4.6 ft	6 sec	SE (134°)
42097 Pulley Ridge	October 26, 2019 1:00 pm CST		3.0 ft	5 sec	ESE (110°)

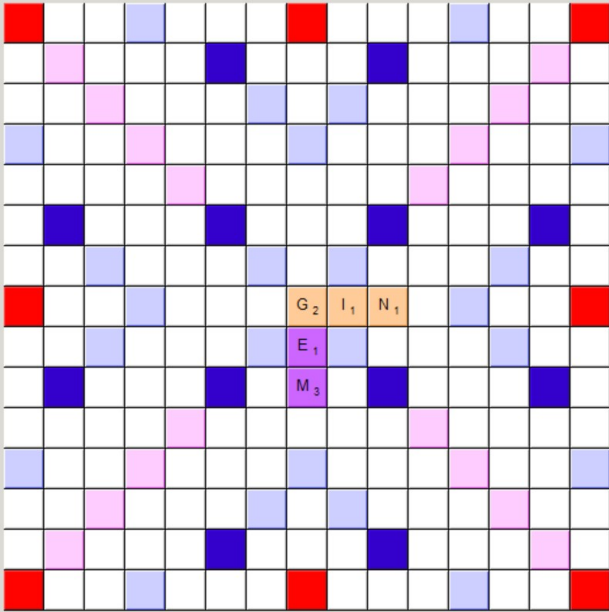
Gotta have some fun!

Scrabble server, running on hamnet!

PyScrabble - guest01

File Tools Server View Help

Chat testGame x



Current Game:

Player	Score
guest01	0
kg6wxc	8

Save Game Leave Game

Chat Info Spectators Options Letter Distribution

[09:53:20 PM] <GAME> testGame started
[09:53:20 PM] <GAME> kg6wxc now has control of the board
[09:53:51 PM] <GAME> kg6wxc has added GIN (8)
[09:53:51 PM] <GAME> guest01 now has control of the board

S₁ A₁ E₁ E₁ I₁

Send Move Pass Move Trade Letters Clear Shuffle

bzflag ("tank") game!



Texas Hold 'Em server :-)

Demo Game - PokerTH 1.1.2 - The Open-Source Texas Holdem Engine

View Settings

Computer7 \$2,940 **Fold**

Computer3 \$6,420 **Check**

Computer8 \$8,920 **Bet** \$80

eric-kg6wxc \$2,540 **Call** \$80

Pot
Total: \$850
Bets: \$160

6♣ A♦ J♣ Q♠

Turn
Game: 1
Hand: 3

Computer1 \$2,780 **Fold**

Orv \$2,600 **BIG BLIND** 6♥ 3♦

Computer4 \$2,790 **Fold**

SMALL BLIND

160 F4 All-in

F3 Raise \$160

F2 Call \$80

F1 Fold

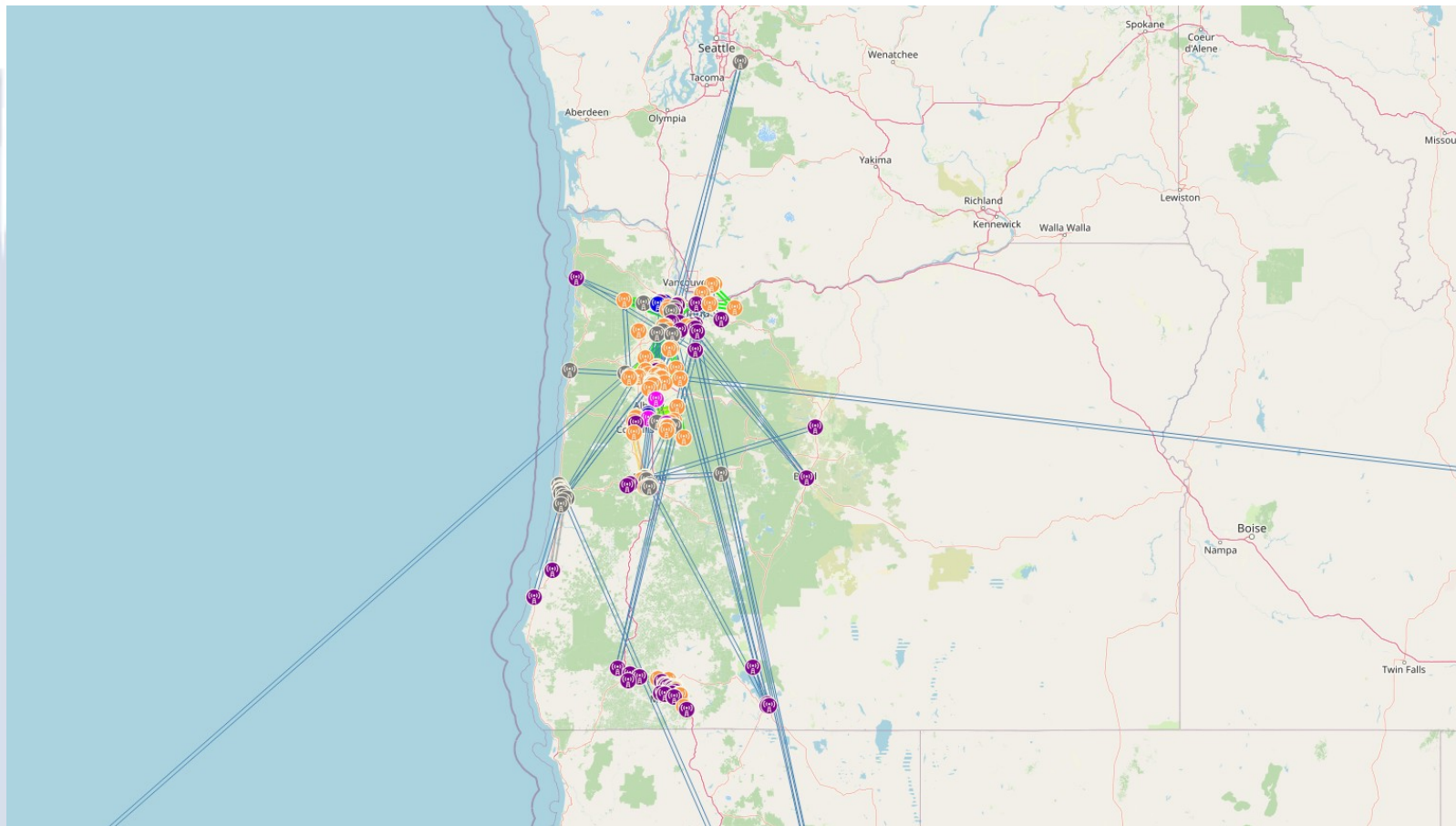
Log Away Chance

eric-kg6wxc: more places to chat too 😊

Computer8 calls \$60.
eric-kg6wxc calls \$60.
Orv calls \$40.
--- Turn --- [6♣, A♦, J♣, Q♠]
Orv checks.
Computer3 checks.
Computer8 bets \$80.
eric-kg6wxc calls \$80.

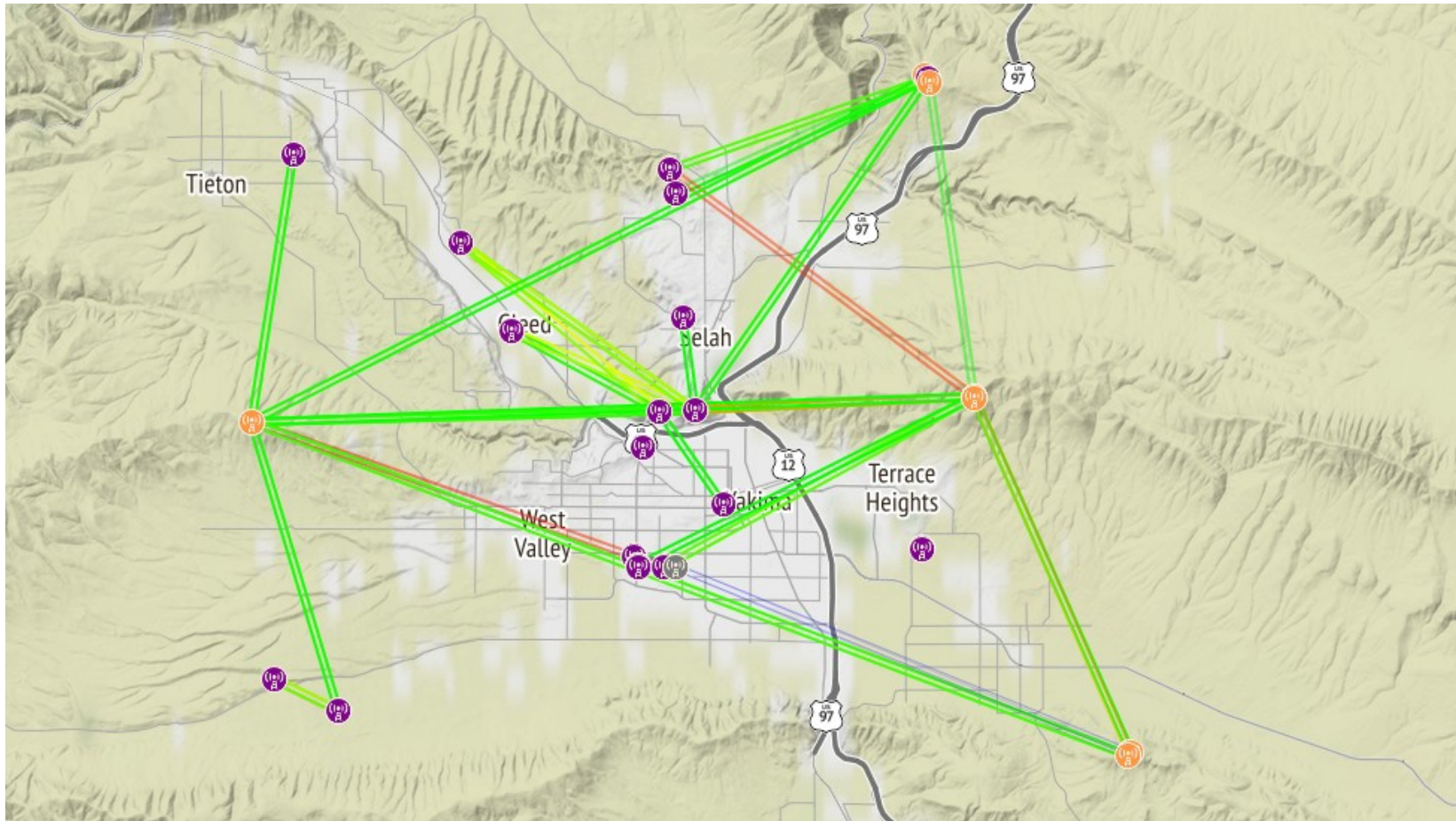
Speed: 5 Lobby

Network maps from KG6WXC mapping software – Washington/Oregon

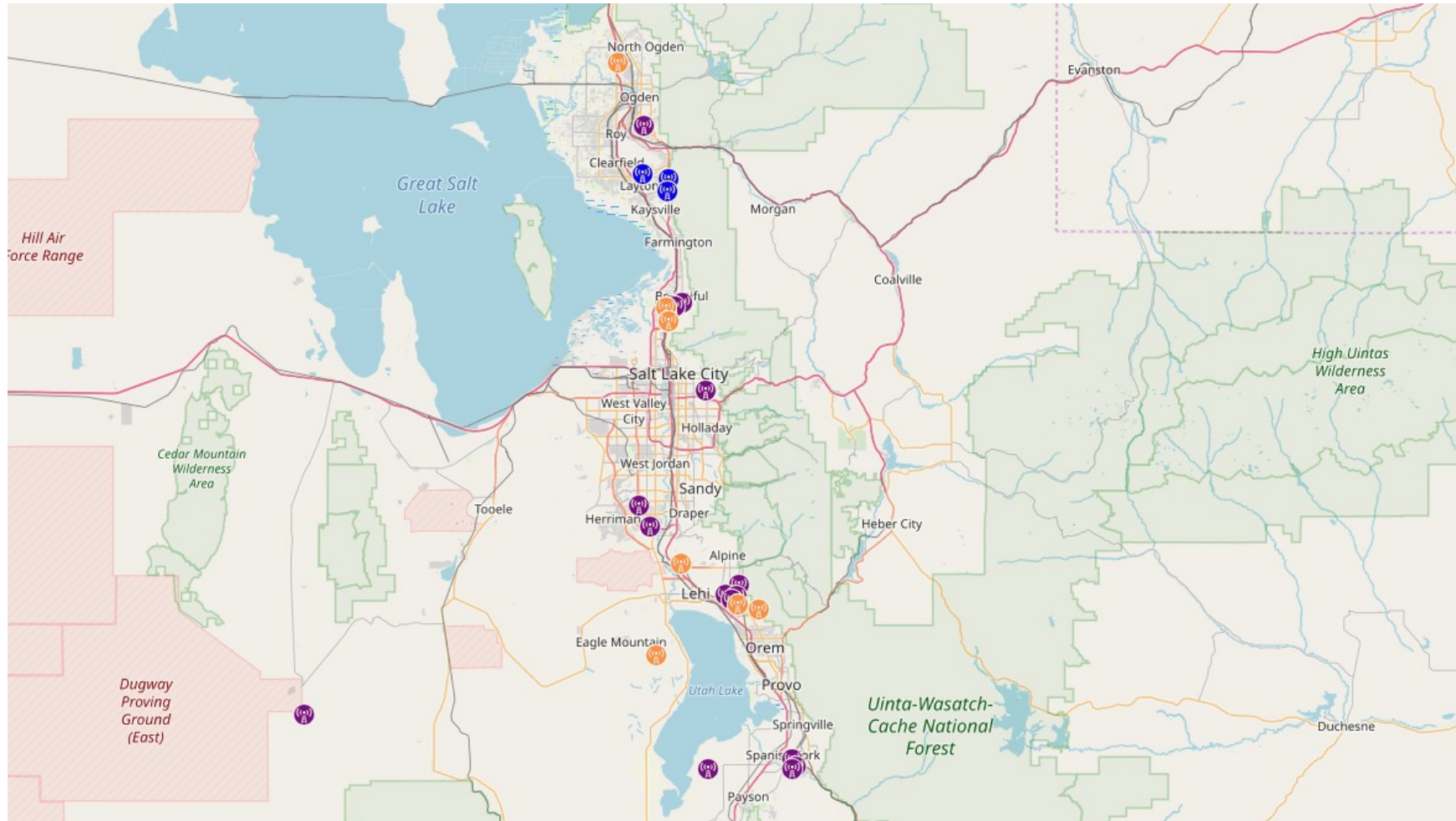


Orange – 5 GHz
Purple – 2 GHz
Blue – 3 GHz
Pink 900 MHz
Grey – no RF

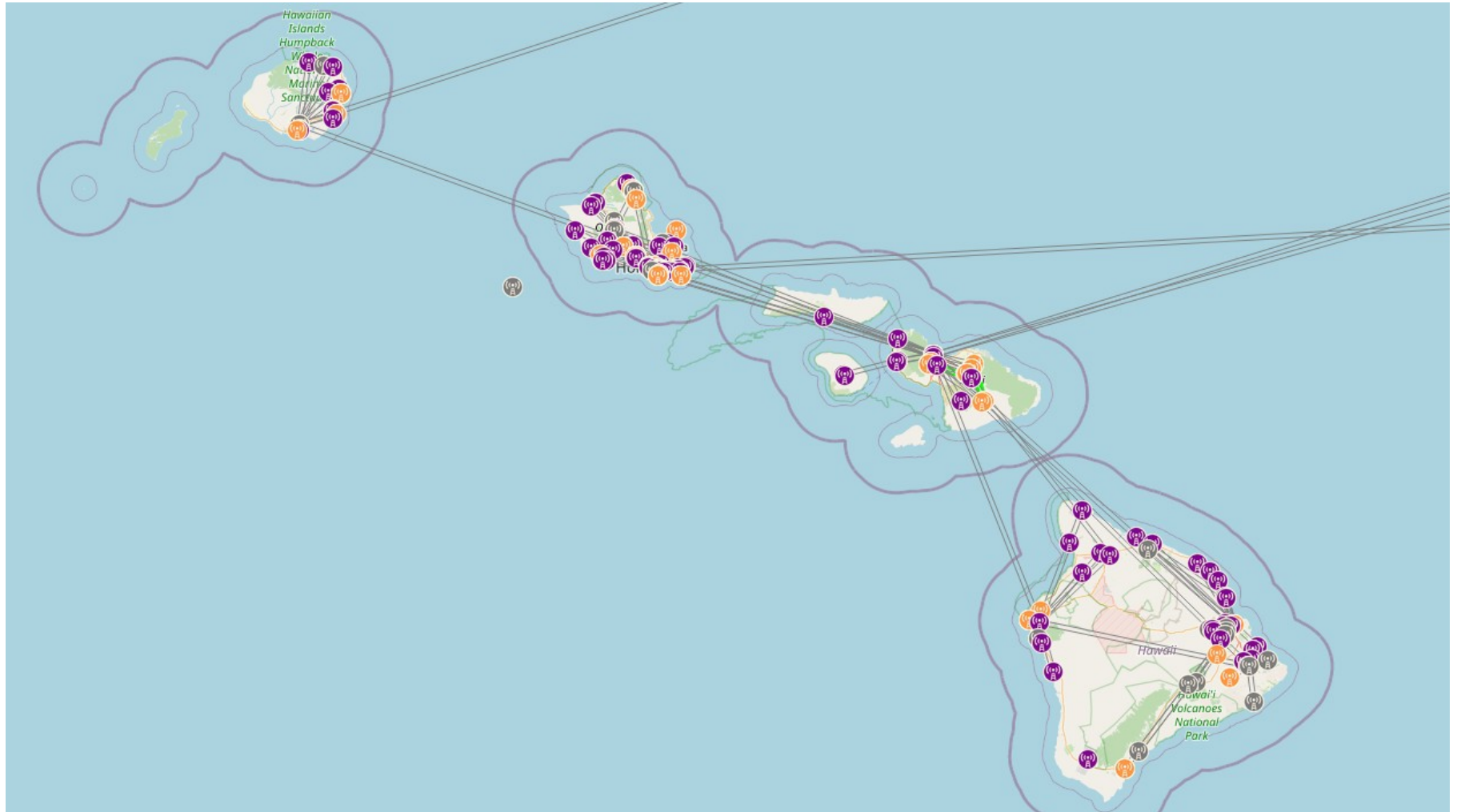
Network map – Yakima, WA



Network map – Salt Lake City, Utah

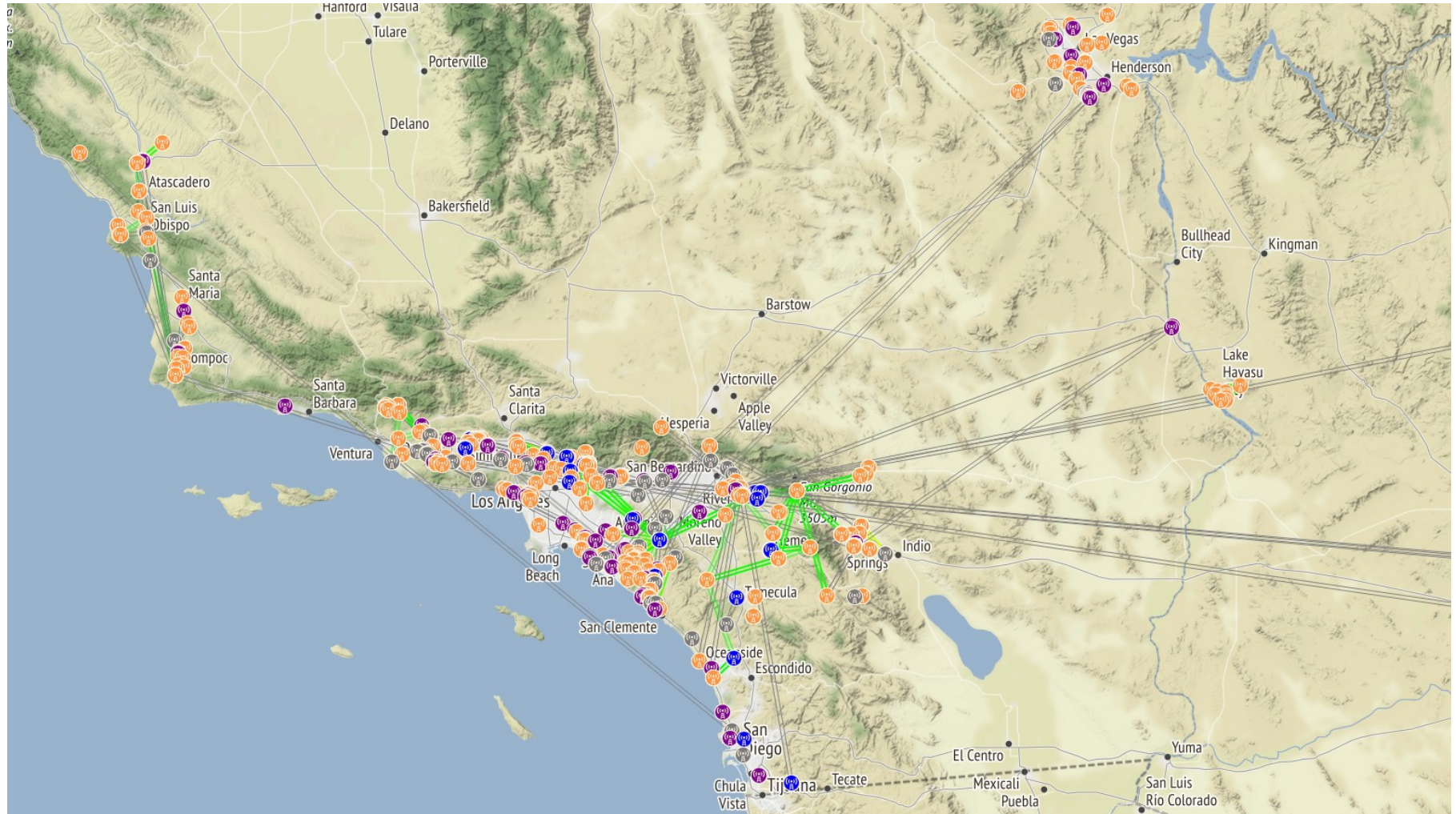


Network map – Hawaiian Islands



Network map – Southern California

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



Equipment

What's out there??

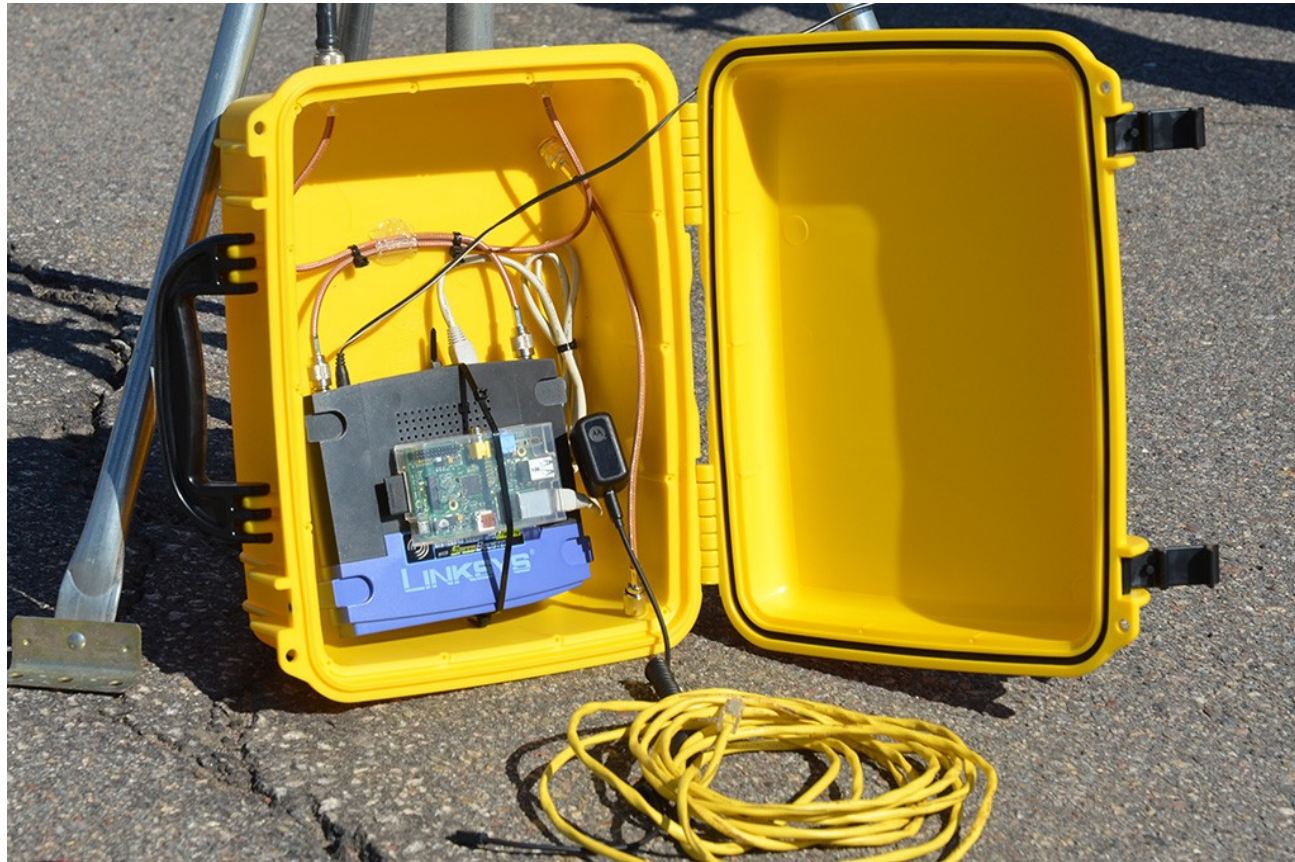
About Modern Access Points/AREDN Nodes

- 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



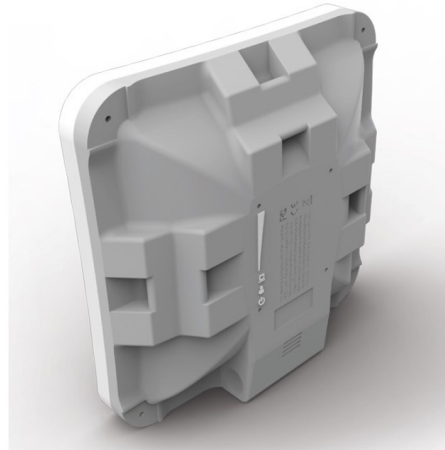
The next generation for the home QTH was the Ubiquiti Nanostation M2* & M5*



*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



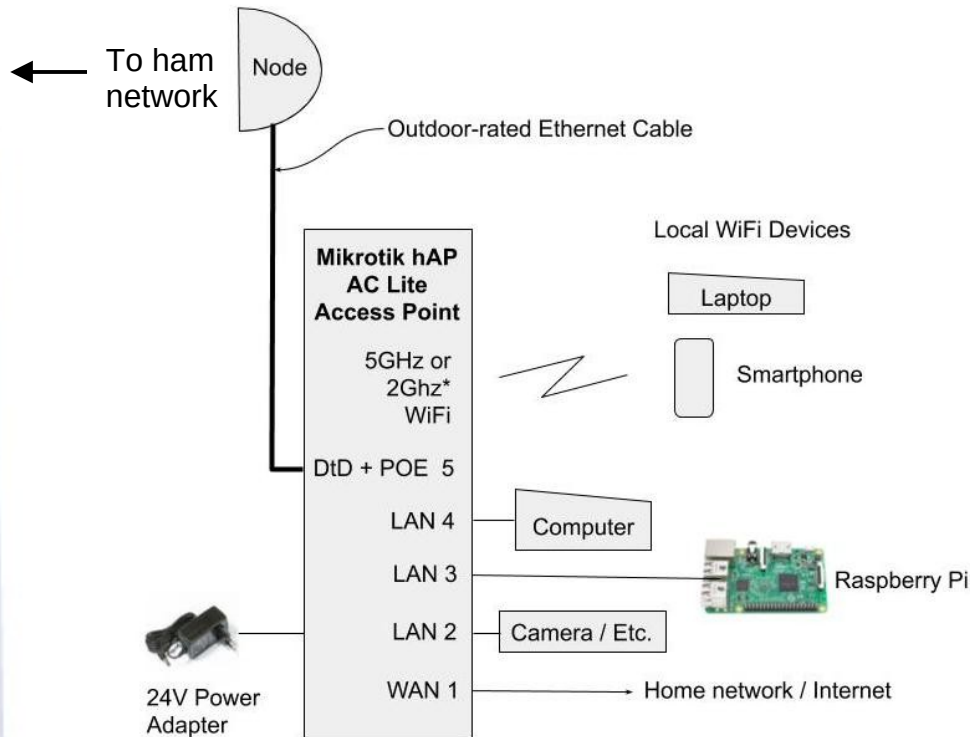
But two's company,
tree's a crowd...

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!



* 2 GHz may be WiFi or Mesh

- 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

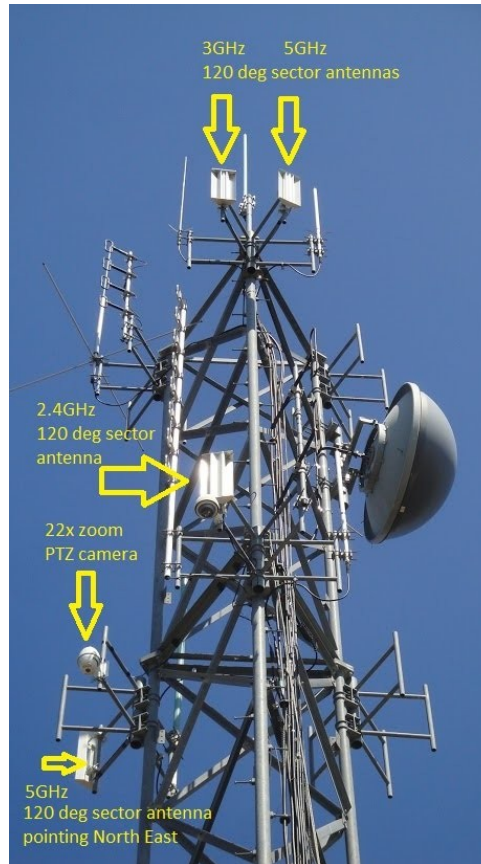


Another medium-sized site (post wind-storm)
(80% FM repeaters, 20% networking) Verdugo Peak, California



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									
Freq	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	
	Status	Ham Band shared with U-NII-3/wifi/unlicensed													
	Freq	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	
	Status	Ham Band shared with U-NII-3/wifi/unlicensed										Ham Band			
	Freq	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	
	Status	Ham Band													
	Freq	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)

K6PVR-VC-SimiEast-5G

Location: 34.260 -118.642

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

[Help](#)

Refresh

Mesh Status

Neighbor Status

WiFi Scan

Setup

Select a theme ▾

Wifi address	10.198.175.154 / 8	Signal/Noise/Ratio	-69 / -95 / 26 dB	Charts
LAN address	10.53.124.209 / 29	firmware version	1796-1a0d51f	
WAN address	none	model	Ubiquiti Rocket M5 XW	
default gateway	10.255.3.22 dtdlink / mid2	system time	Sun Oct 16 2022 20:06:34 PDT	
		uptime	3 days, 0:12	
SSID	AREDN-10-v3	load average	0.19, 0.16, 0.17	
Channel	170	free space	flash = 2448 KB /tmp = 29068 KB memory = 29536 KB	
Bandwidth	10 MHz	Host Entries	Total = 1235 Nodes = 458	

The AREDN node interface – mesh status page

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

Local Host	Services	Current Neighbors	LQ	NLQ	TxMbps	Services
K6PVR-VC-SimiEast-5G <ul style="list-style-type: none">simieast-srvsimieast-phonesimieast-cam1	Site-Info	10.148.29.209 <ul style="list-style-type: none">aa6kj	61%	100%	21.6	AREDN mirror DX Cluster Home page Network stats smtp
Remote Nodes	ETX	Services				
K6PVR-VC-SouthMtn-SF-Sector-5G (tun*3)	0.20					
K6PVR-VC-SouthMtn-W-Sector-5G	0.30					
K6PVR-VC-Sulphur-ResourceServer (tun*2) <ul style="list-style-type: none">k6pvr-mailk6pvr-ebv--4305k6pvr-sulphur-4080k6pvr-bridgek6pvr-pbxk6pvr-svr	0.30	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) <ul style="list-style-type: none">rasnow-srv	0.40	Site_Status				Asterisk PBX (10.38.100.194) FTP IPERF & IPERF3 IRC NTP (stratum 1) Node info Weather station Webcam snapshots
K6PVR-VC-TUNNEL-SRV (tun*2)	0.50					
K1BLU-Home-Router (tun*1) <ul style="list-style-type: none">rreid-Aspire-X3910	0.60					

Remote nodes (more than one hop)

Local neighbors and the services they are providing

Current Neighbors	LQ	NLQ	TxBps	Services
10.148.29.209	76%	100%	21.6	
• aa6kj				AREDN mirror DX Cluster Home page Network stats smtp IperfSpeed
K6BFG-LA-MgcMtn-NW-Sector (tun)	100%	100%		
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

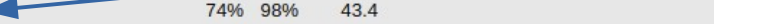
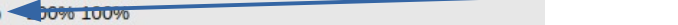
Local linked neighbors (not direct RF; DtD via Ethernet cable, or other)

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-OTH-2.local.mesh	1.17	
KE6WEZ-VC-MELLOW-LANE-5G.local.mesh	1.20	
W6BI-TEST-2G.local.mesh	1.20	IperfSpeed
W6BI-VC-OTH-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!**