

Using AREDN Software to Create a Ham Radio IP Network

Updated 11/13/2023 – Vers. 5.5

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Data Rates for Ham Radio Digital Modes

Comparing modulation rates, not throughput:

- Packet radio: 1200 baud (.0012 Mbit/sec <!>)
- PACTOR 3 (HF): ~ 10-20 kbits/sec
- VARA FM: up to 25 kbits/sec (w/specific gear)
- AREDN ham radio network links can run over 100 Mbit/sec

Amateur Radio Emergency Data Network (AREDN) Software as of 11/13/2023

Supports:

- Four brands of equipment, 100+ different models (~20 no longer recommend for new deployment), across four ham bands
- Internet tunneling between nodes, to bridge RF gaps (requires addition of Mikrotik hAP AC (Lite or ac2 or ac3 to shack network)
- Allows operations in Part 97 (ham) channels
- MIMO (Multiple Input / Multiple Output) + 802.11n (**now 802.11ac!**) 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~~ quadruple 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're allowing Part 15 users to spread into the entire band now.

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**

Messaging

- Email servers & clients:
 - ◆ Standard email servers (configured for mesh network)
 - ◆ Thunderbird client, etc.
 - ◆ Web clients are available (e.g., Roundcube)
 - ◆ Can send & receive to/from Internet mail (if server is configured for it)

Thunderbird configured for both gmail and mesh mail

The screenshot displays the Mozilla Thunderbird email client interface. The title bar shows the current account: "Inbox - w6bi@k6pvr-mail.local.mesh - Mozilla Thunderbird". The menu bar includes File, Edit, View, Go, Message, Tools, and Help. The address bar shows the current account. The toolbar includes "Get Messages", "Write", "Tag", and "Quick Filter". A search bar is located on the right side of the toolbar.

The left sidebar shows the "Folders" pane with two accounts:

- orv.beach@gmail.com**
 - Inbox
 - Winlink+VARA
 - Trash
 - [Gmail]
 - Drafts
 - Sent Mail
 - All Mail (100)
 - Spam (97)
 - Trash (v127)
 - HamNet
 - Important (35)
 - Starred
 - [Probably SPAM]
 - Board
 - Family
 - Friends
- w6bi@k6pvr-mail.local.mesh**
 - Inbox
 - Drafts
 - Sent
 - Trash
 - Local Folders
 - Junk
 - Trash
 - Outbox
 - Drafts-orv.beach@gmail.com
 - Sent Mail-orv.beach@gmail.com

The main pane displays a list of emails from the selected account (w6bi@k6pvr-mail.local.mesh). The list has columns for Subject, Correspondents, and Date.

Subject	Correspondents	Date
Re: testing mesh email	→ Orv Beach	5/24/23, 17:32
Test email	Dave Schmidt	3/29/23, 22:23
Re: Welcome	Bob KJ6GEU	3/25/23, 17:29
Re: Welcome	Bob KJ6GEU	3/25/23, 17:27
Re: Welcome	Bob KJ6GEU	3/25/23, 13:44
Re: testing meshmail	→ Orv Beach	3/21/23, 15:05
Testing from GMAIL	Eric Satterlee	3/18/23, 17:26
Testing	n6rfi@k6pvr-mail.local.mesh	3/14/23, 19:10
Re: Greetings via MeshMail	Mark Herson, N2MH	3/14/23, 18:00
Greetings via MeshMail	n2mh@n2mh-mailhub.local.mesh	3/14/23, 17:37
Re: Welcome	Wayne Francis	3/8/23, 17:52
Re: Welcome	w2ayz@k6pvr-mail.local.mesh	3/7/23, 08:39
Re: Welcome	N6RFI	3/6/23, 15:45
Re: testing	Eric	3/5/23, 22:12
testing	Eric	3/5/23, 21:21

Roundcube web email reading mesh email account

K6PVR Mesh Email :: Inbox — Mozilla Firefox

File Edit View History Bookmarks Tools Help

https://k6pvr-mail.local.mesh/?_task=mail&_mbox=INBOX

Communicate Info Tech Wx Ham Radio HamNet Keep Amazon Feedy Health Entertainment SCALE Genealogy Finance Google Maps

w6bi@k6pvr-mail.local.mesh

Select Threads Options Refresh

Reply Reply all Forward Delete Mark More

Compose

Mail

Contacts

Settings

Inbox

Drafts

Sent

Trash

af6xt@k6pvr-mail.local.mesh 2023-06-07 09:55

Mail Setup

af6xt@k6pvr-mail.local.mesh 2023-06-07 09:47

- Re: Welcome

Orv Beach 2023-05-24 17:32

- Re: testing mesh email

David Schmidt AI6VX 2023-03-29 22:23

Test email

Bob KJ6GEU 2023-03-25 17:29

Re: Welcome

Bob KJ6GEU 2023-03-25 17:27

- Re: Welcome

Bob KJ6GEU 2023-03-25 13:44

Re: Welcome

Orv Beach 2023-03-21 15:05

- Re: testing meshmail

kg6wxc Eric 2023-03-18 17:26

- Testing from GMAIL

Mail Setup

From af6xt@k6pvr-mail.local.mesh on 2023-06-07 09:55

[Details](#) [Headers](#)

I may have succeeded
Thanks,
Barry
AF6XT

Winlink

(Winlink Global Radio Email)

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

- **On HF**
- ALE (Automatic Link Establishment)
- AX.25 Packet Radio
- 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, when authorized by FCC

Winlink

On VHF

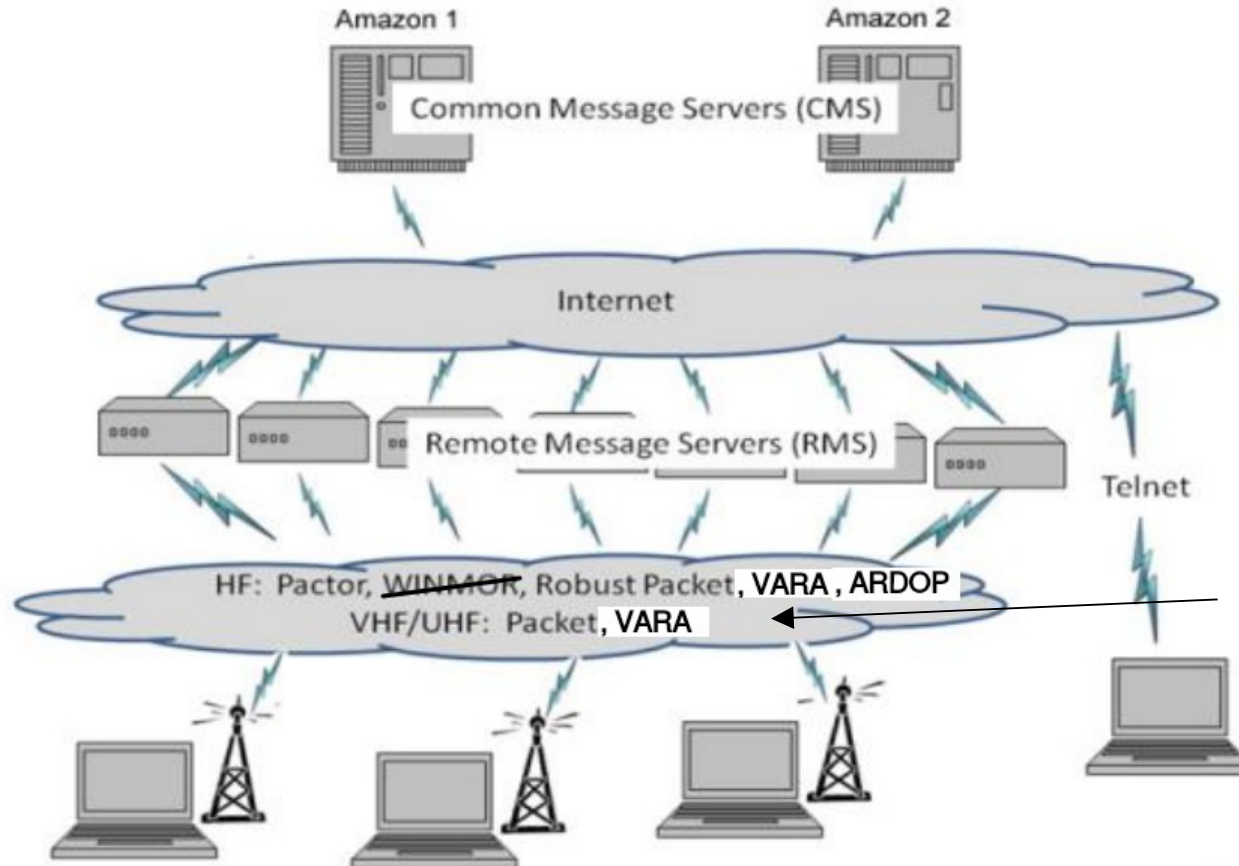
- AX.25 Packet Radio
- APRS
- VARA/FM
- AREDN network
 - ◆ much faster, no digipeating required
- Has a large set of standardized messaging templates. (e.g. ICS, USGS, FEMA)

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...	S33XEUVJO2...	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...	111BSVR6ZFI	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]

System Folders:
Inbox (0 unread)
Read Items (0)
Outbox (0)
Sent Items (51)
Saved Items (0)
Deleted Items (2)
Drafts (0)

Personal Folders

Global Folders

Contacts:
5022803062@VTEXT.COM
5052803062@VTEXT.COM
8055513008@VTEXT.COM
8055513008@VZWPIX.COM
AB6BW
AI6BX
AJ7C
KE6MLF
KE6WEZ
KG6WXC
ORV.BEACH@GMAIL.COM
W2AYZ
W6BI
WINLINK@VCCOMM.ORG

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

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

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.			

Which channel to send the message to

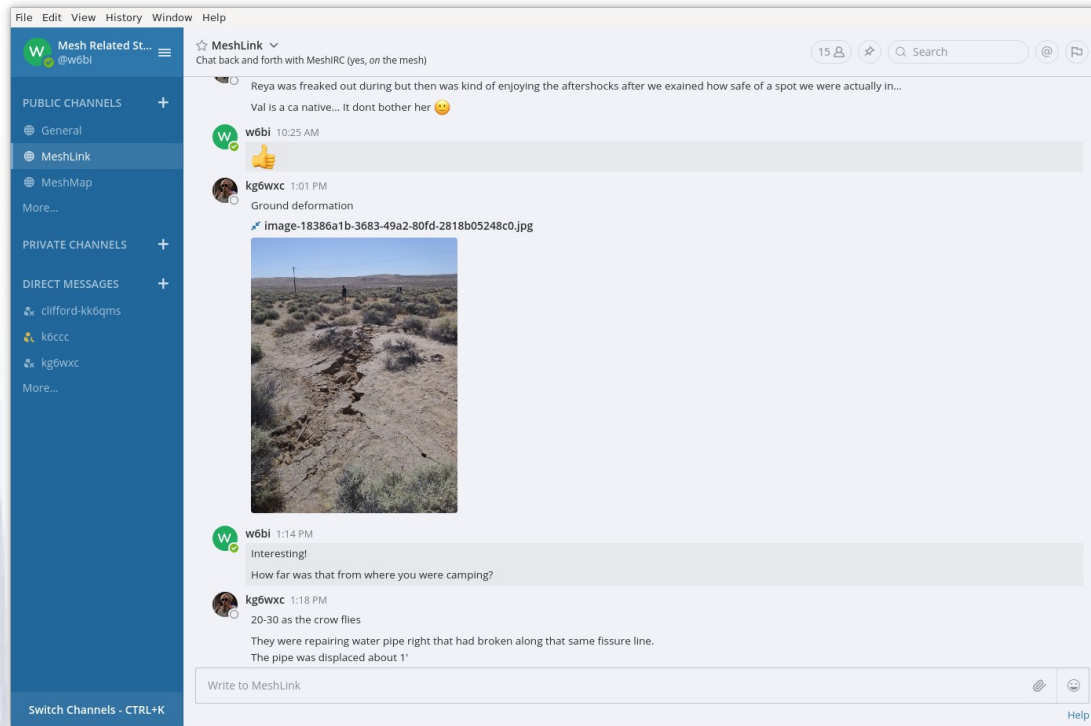
Messages in the db

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 ~\$275



- 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 50-100 kbps (up & down) – 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 displays 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". The toolbar contains icons for various functions. The main window is titled "K6PVR Ventura County Teamtalk (14)".

User List:

Username	✓	✓	✓	✓
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 Log:

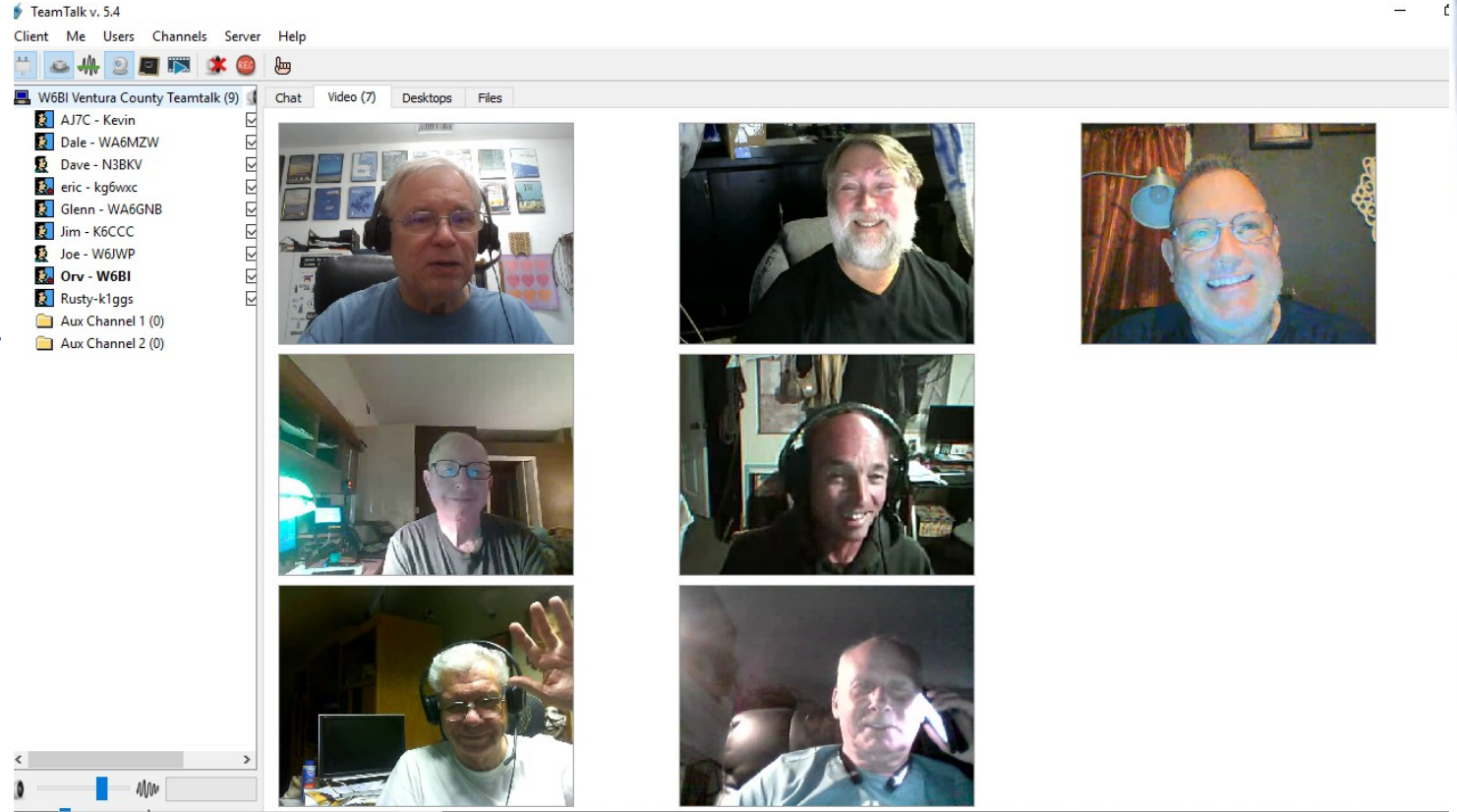
2020-04-15T20:04:05 *Ryan - K1BLU - Lakewood left channel
2020-04-15T20:04:11 *Ryan - K1BLU - Lakewood joined channel
2020-04-15T20:04:18 *Endaf - N6UTC Long Beach. joined channel
2020-04-15T20:06:26 <Endaf - N6UTC Long Beach. > no im here
2020-04-15T20:07:49 *K3CAQ Andy Thousand Oaks joined channel
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 interface also shows audio and video controls at the bottom, with RX: 0.00KB TX: 0.00KB and a "Send" 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](#)

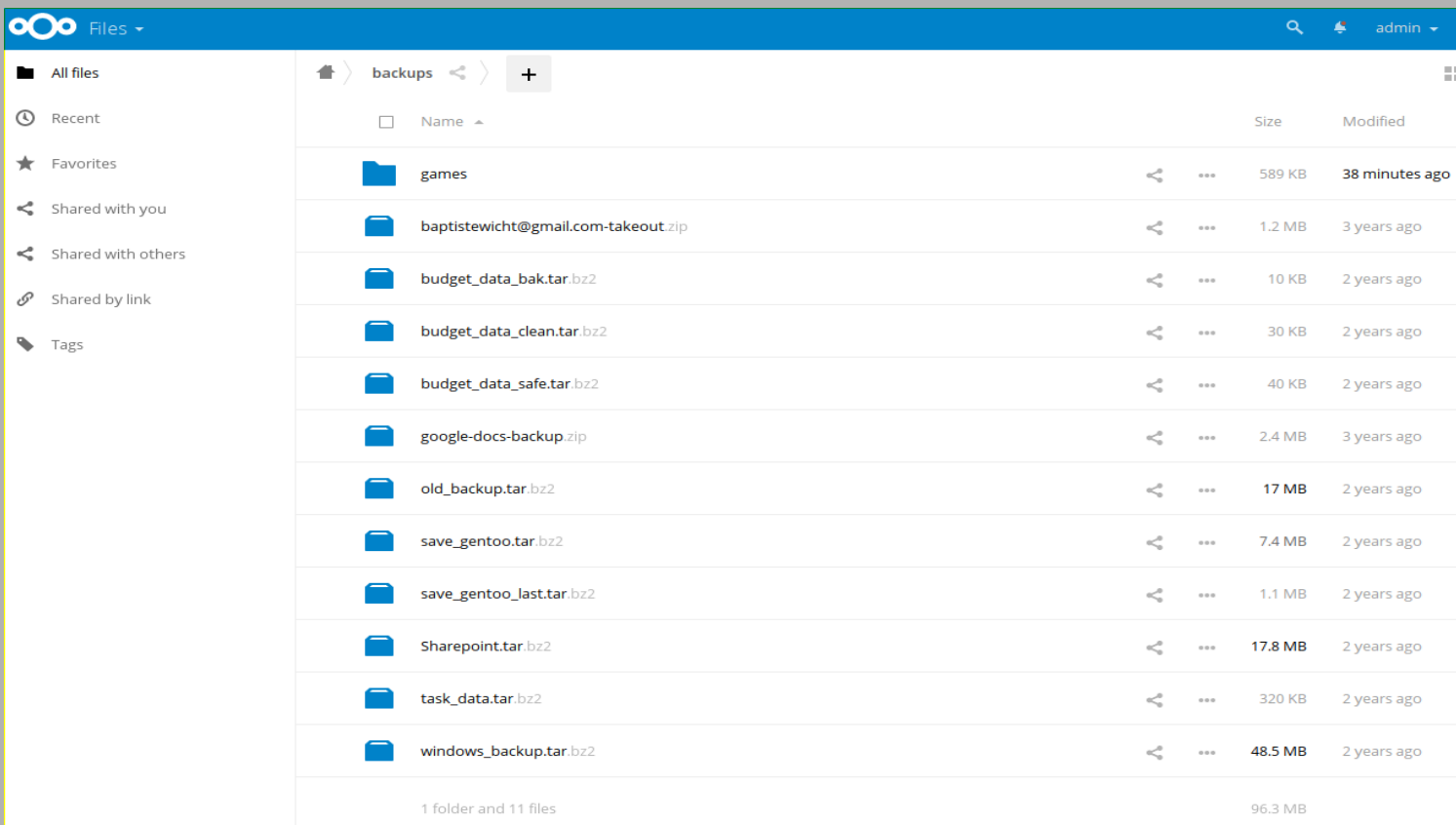
Options

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

Feedback

Powered by [AppJet](#) →

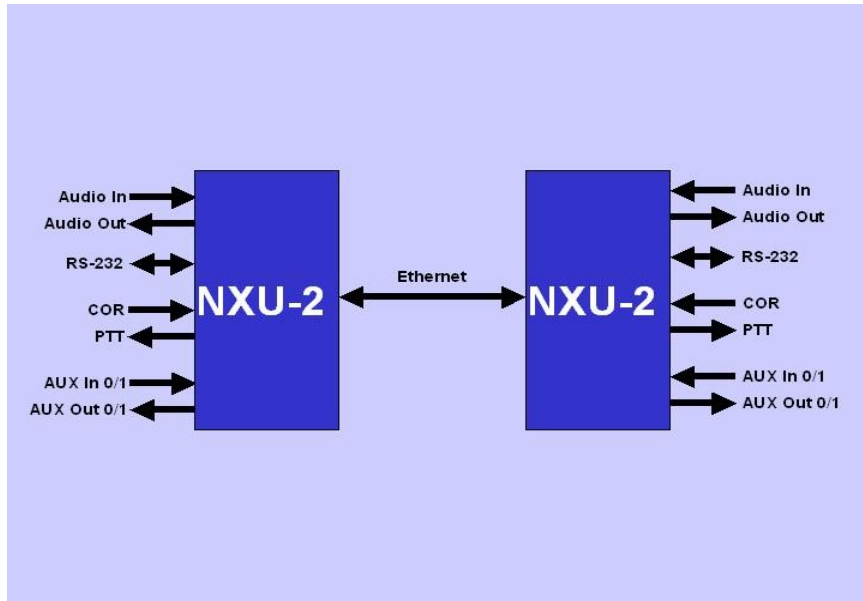
NextCloud – a drop box



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 notification bell, 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' directory with a table of files and folders. The table has columns for 'Name', 'Size', and 'Modified'. The files listed include a 'games' folder and several backup files with their respective sizes and modification times. A summary row at the bottom indicates '1 folder and 11 files' with a total size of '96.3 MB'.

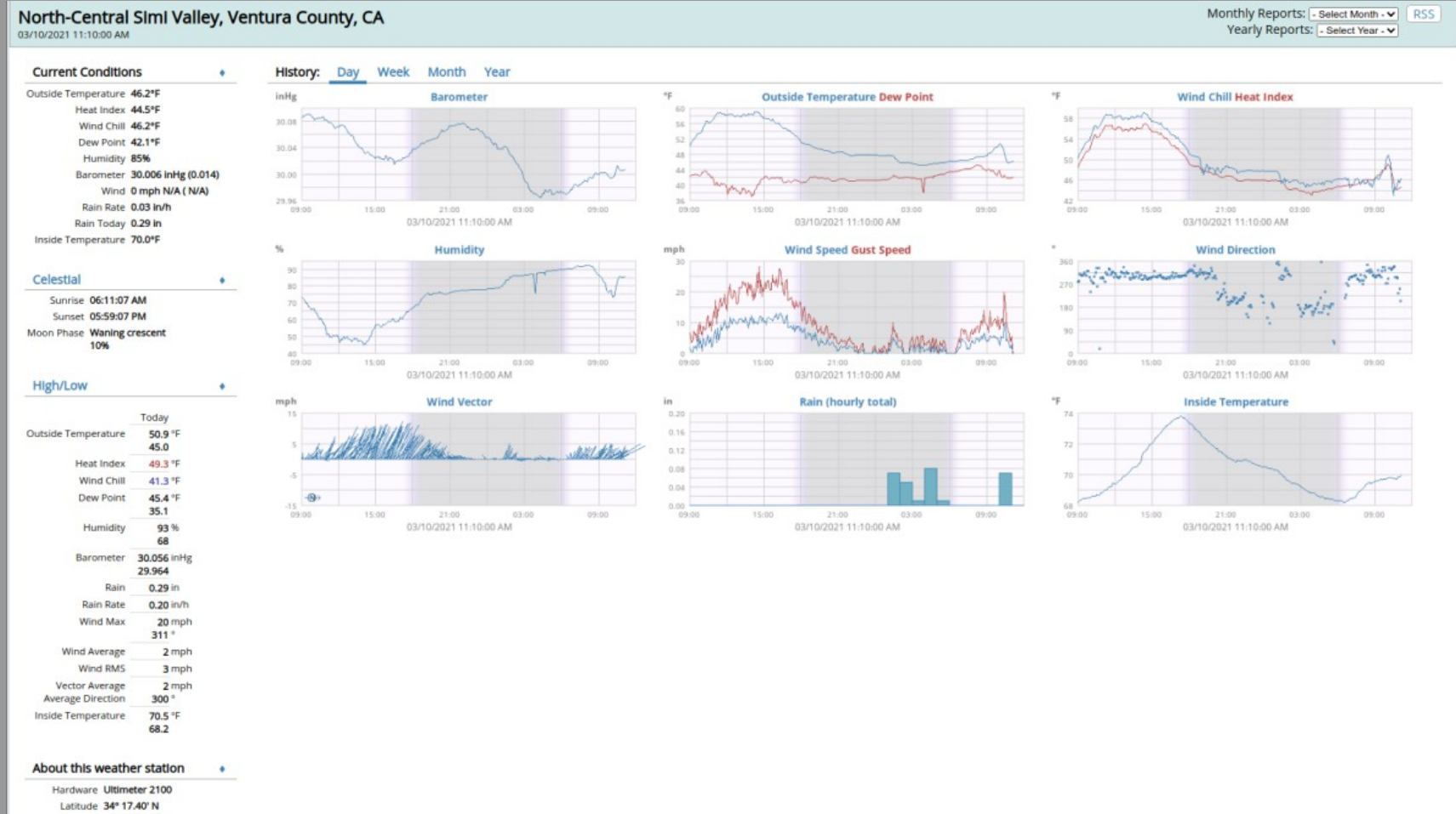
Name	Size	Modified
games	589 KB	38 minutes ago
baptistewicht@gmail.com-takeout.zip	1.2 MB	3 years ago
budget_data_bak.tar.bz2	10 KB	2 years ago
budget_data_clean.tar.bz2	30 KB	2 years ago
budget_data_safe.tar.bz2	40 KB	2 years ago
google-docs-backup.zip	2.4 MB	3 years ago
old_backup.tar.bz2	17 MB	2 years 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, Orion Systems, 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

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	Time/Date
venf1 Venice Pier	October 26, 2019 1:00 pm EST	82.4°F (28.0°C)	October 26, 2019 1:00 pm CST
42098 Egmont Channel	October 26, 2019 1:00 pm CST		October 26, 2019 1:00 pm CST
42099 Offshore St. Pete	October 26, 2019 1:00 pm CST		October 26, 2019 1:00 pm CST
42097 Pulley Ridge	October 26, 2019 1:00 pm CST		October 26, 2019 1:00 pm CST

Parameter	Value
Water Temperature	82.4°F (28.0°C)
Wind Speed	:14.0 knots
Wind Gusts	:15.0 knots
Wind Direction	:S (190°)
Wave Height	:4.3 ft
Wave Period	:5 sec
Wave Direction	:SSE (168°)
Wave Height	:4.6 ft
Wave Period	:6 sec
Wave Direction	:SE (134°)
Wave Height	:3.0 ft
Wave Period	:5 sec
Wave Direction	:ESE (110°)

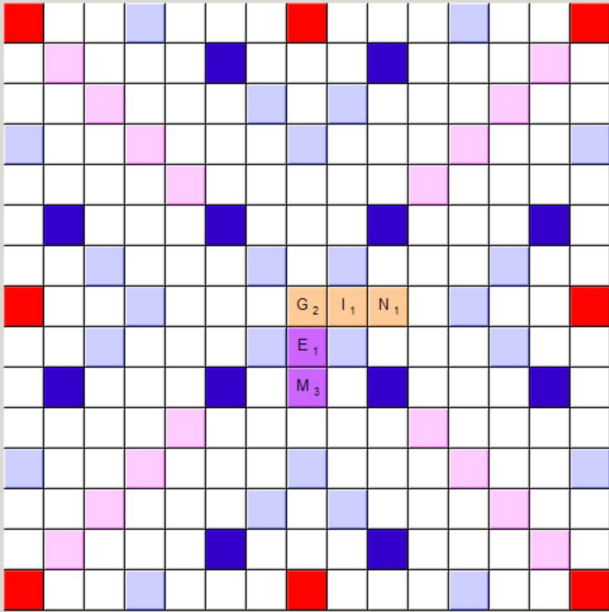
Gotta have some fun!

Scrabble server, running on hamnet!

PyScrabble - guest01

File Tools Server View Help

Chat testGame x



The image shows a Scrabble board with a 15x7 grid. The board is partially filled with letters. The word "GIN" is highlighted in orange in the 5th row, 8th to 10th columns. The word "EAT" is highlighted in purple in the 6th row, 7th to 9th columns. The word "MINE" is highlighted in blue in the 7th row, 4th to 9th columns. The board also features various colored squares: red (corners), blue (double letter), pink (triple letter), and light blue (double/triple word).

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

DEALER

SMALL BLIND

Computer1 \$2,780 **Fold**

Orv \$2,600 **Big Blind**
6♥ 3♦

Computer4 \$2,790 **Fold**

Hands Chat

eric-kg6wxc: more places to chat too 😊

160 F4 All-in

F3 Raise \$160

F2 Call \$80

F1 Fold

Log Away Chance

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

Cameras!



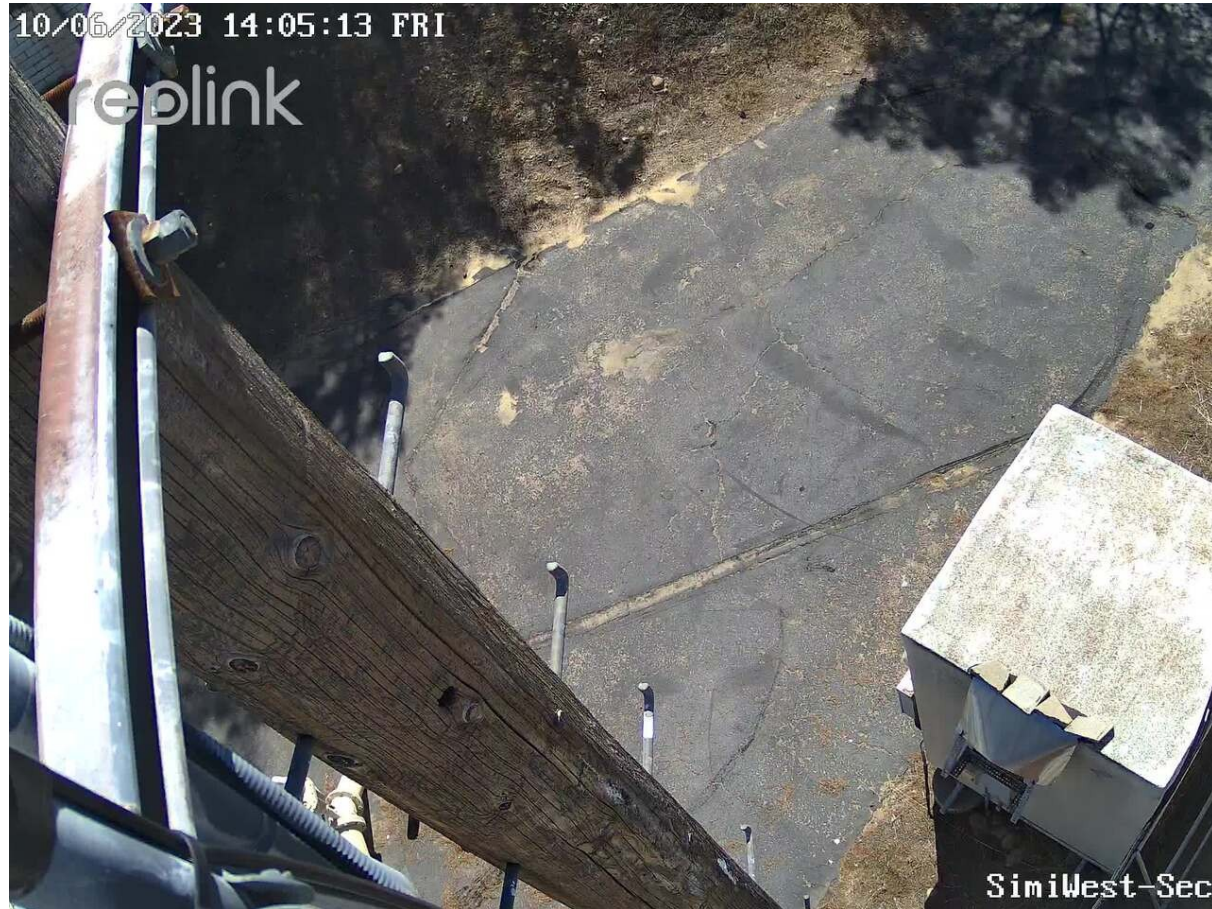
Cameras!

05/06/2023 15:37:46



SimiWest-West PTZ

Cameras!



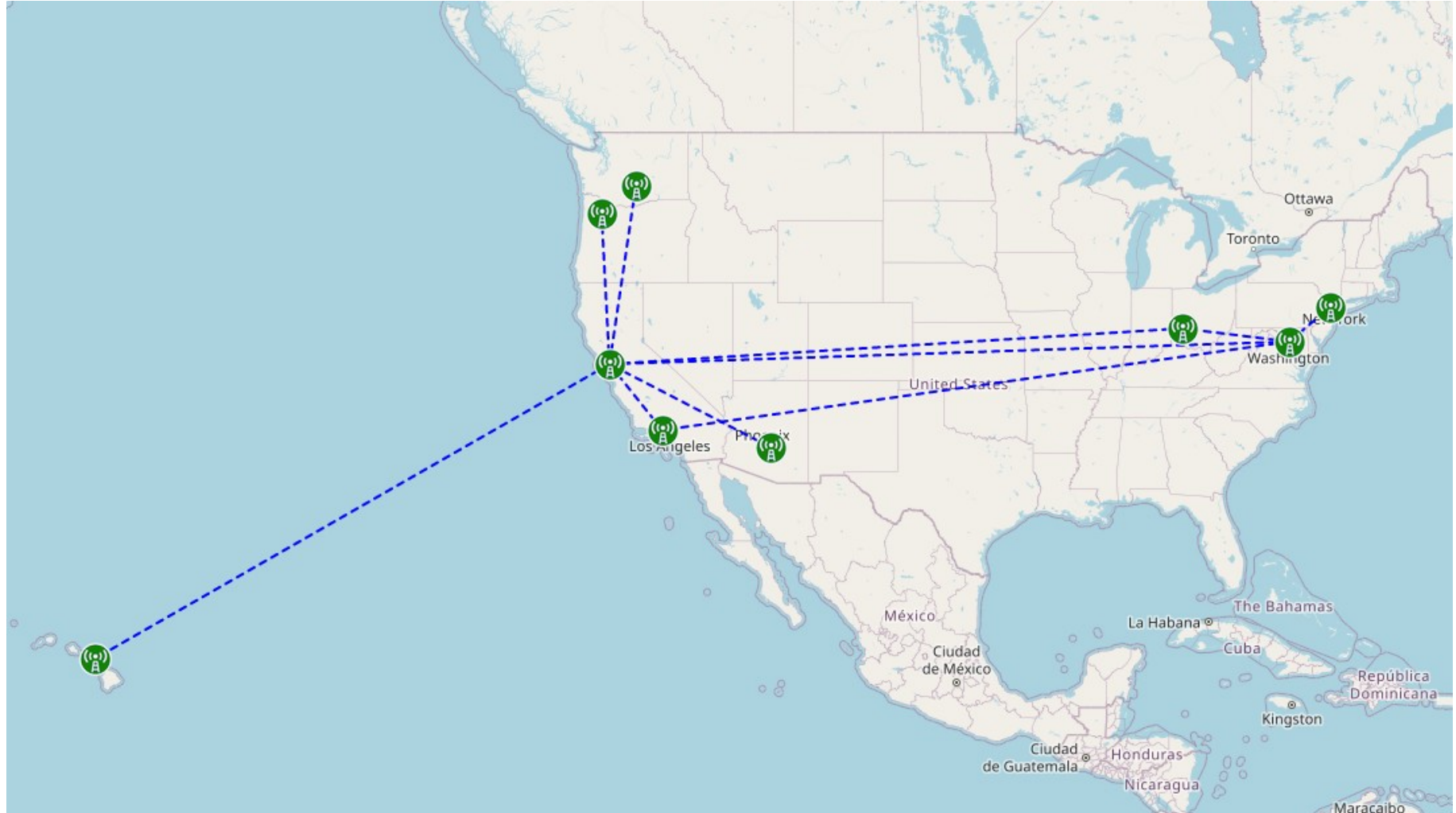
Cameras!



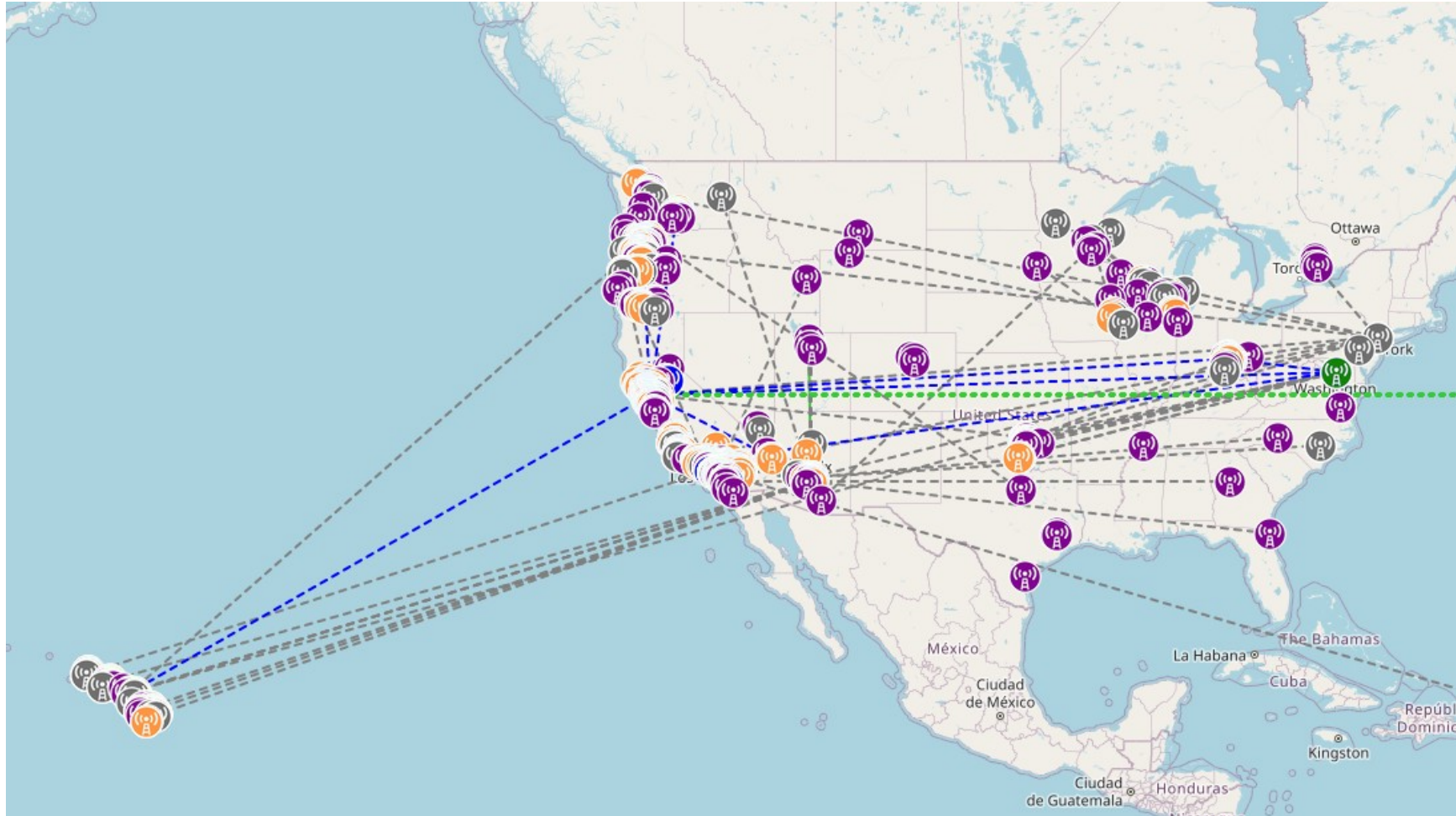
06/20/2023 14:45:13 TUE

KB6BF Pismo Cam

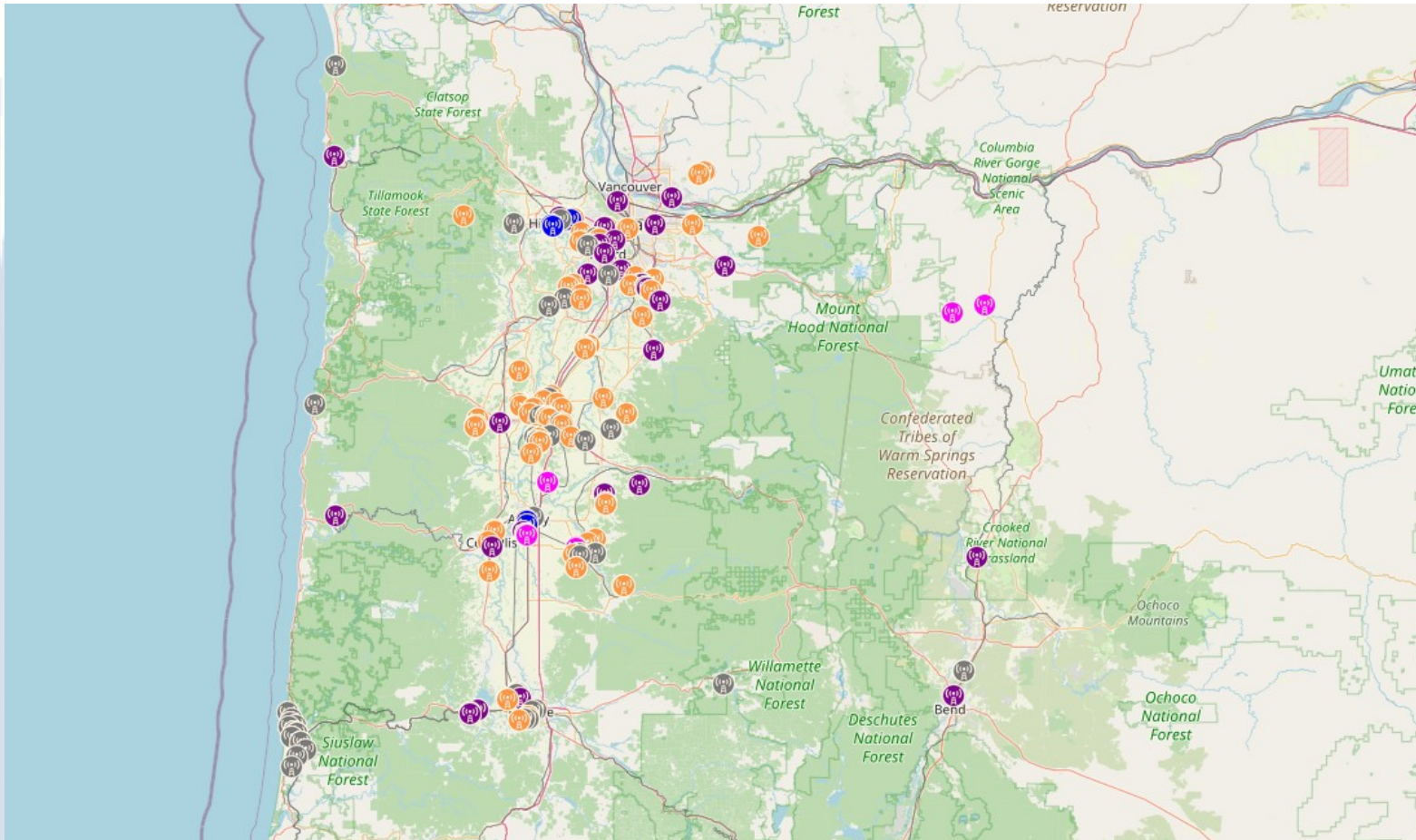
Network map – (supernode network)



Network map – (supernode view)

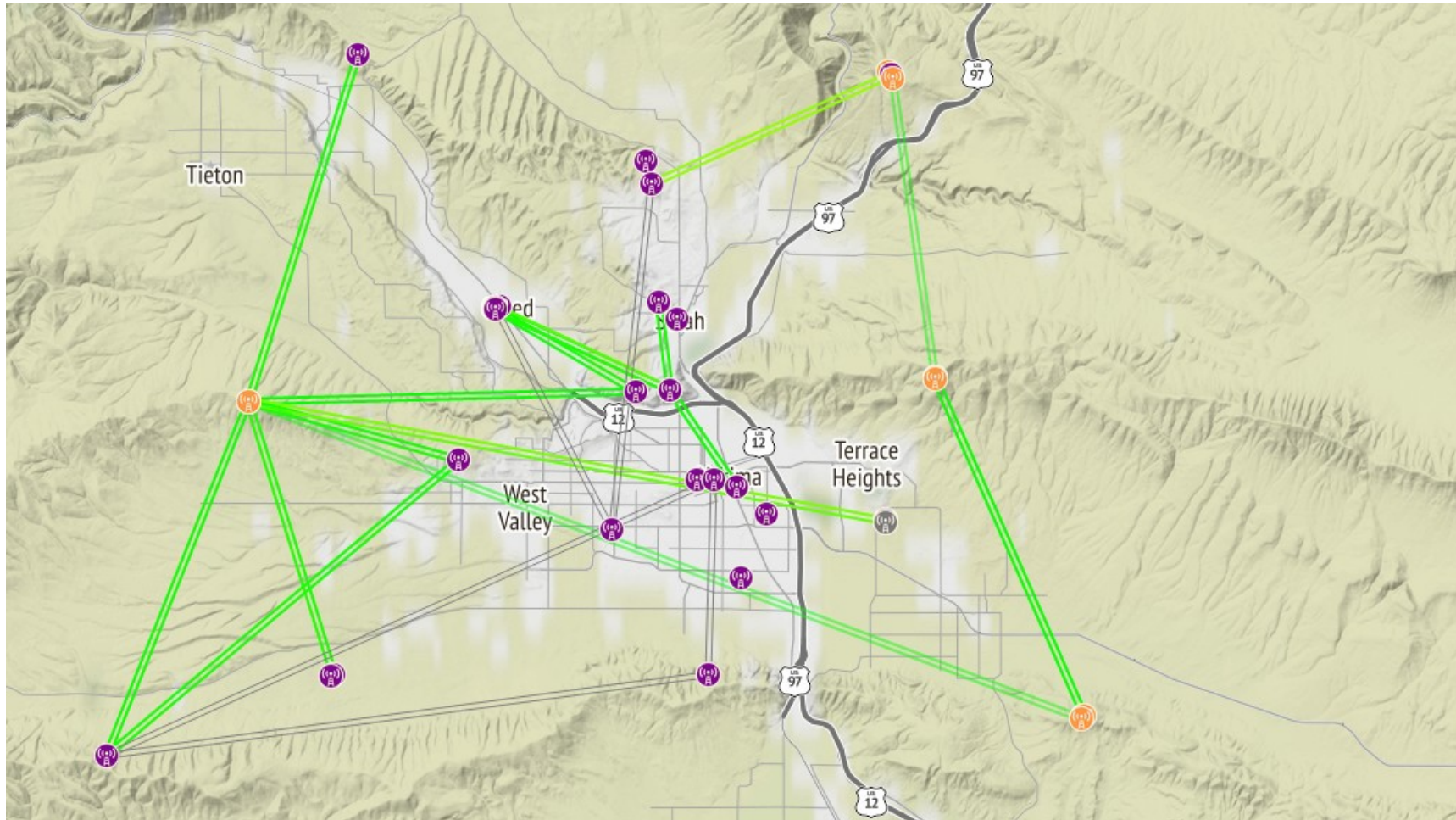


Network map - Washington/Oregon

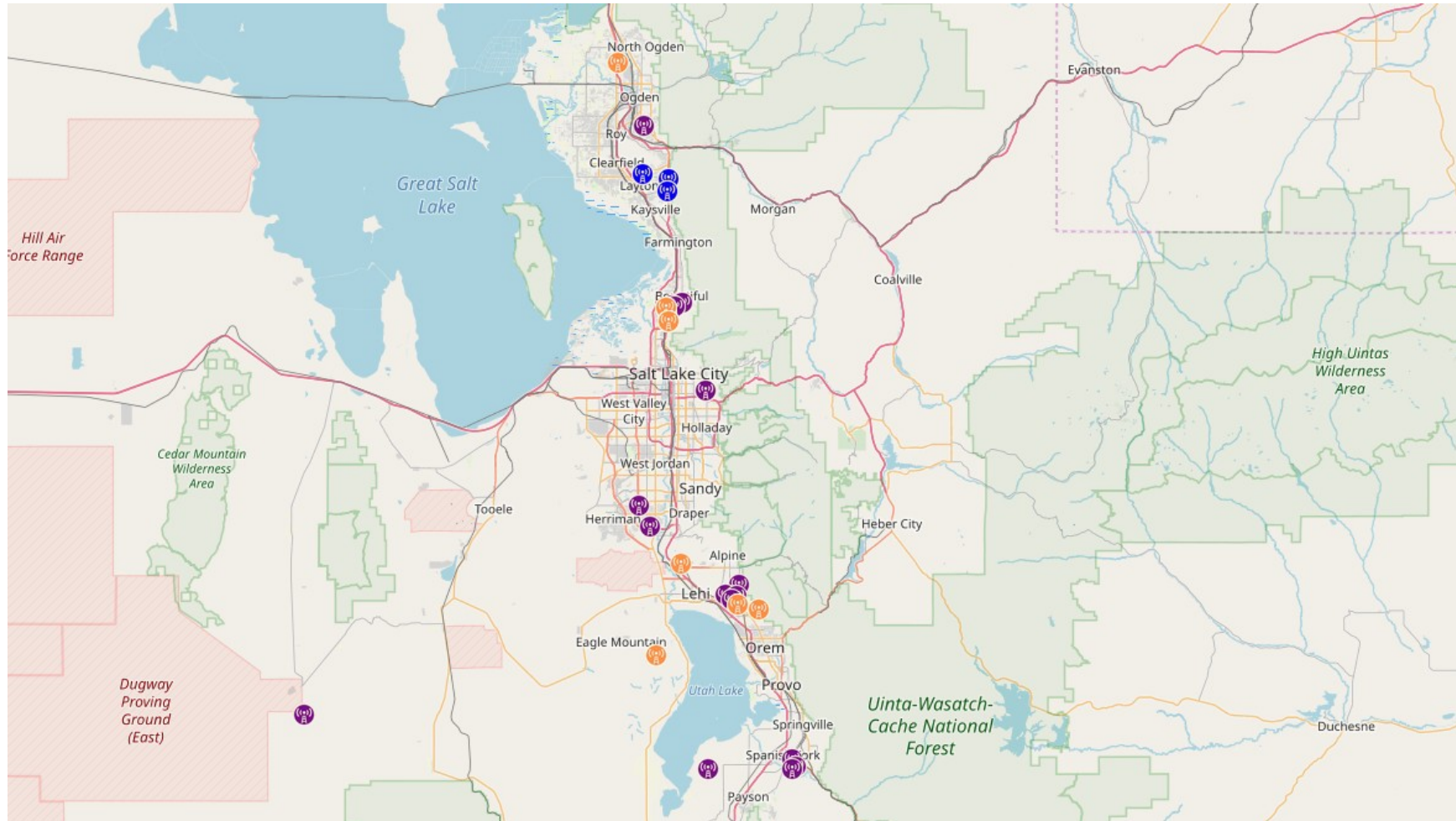


Orange – 5 GHz
Purple – 2 GHz
Blue – 3 GHz
Pink 900 MHz
Grey – no RF
(usually a Hap ac)

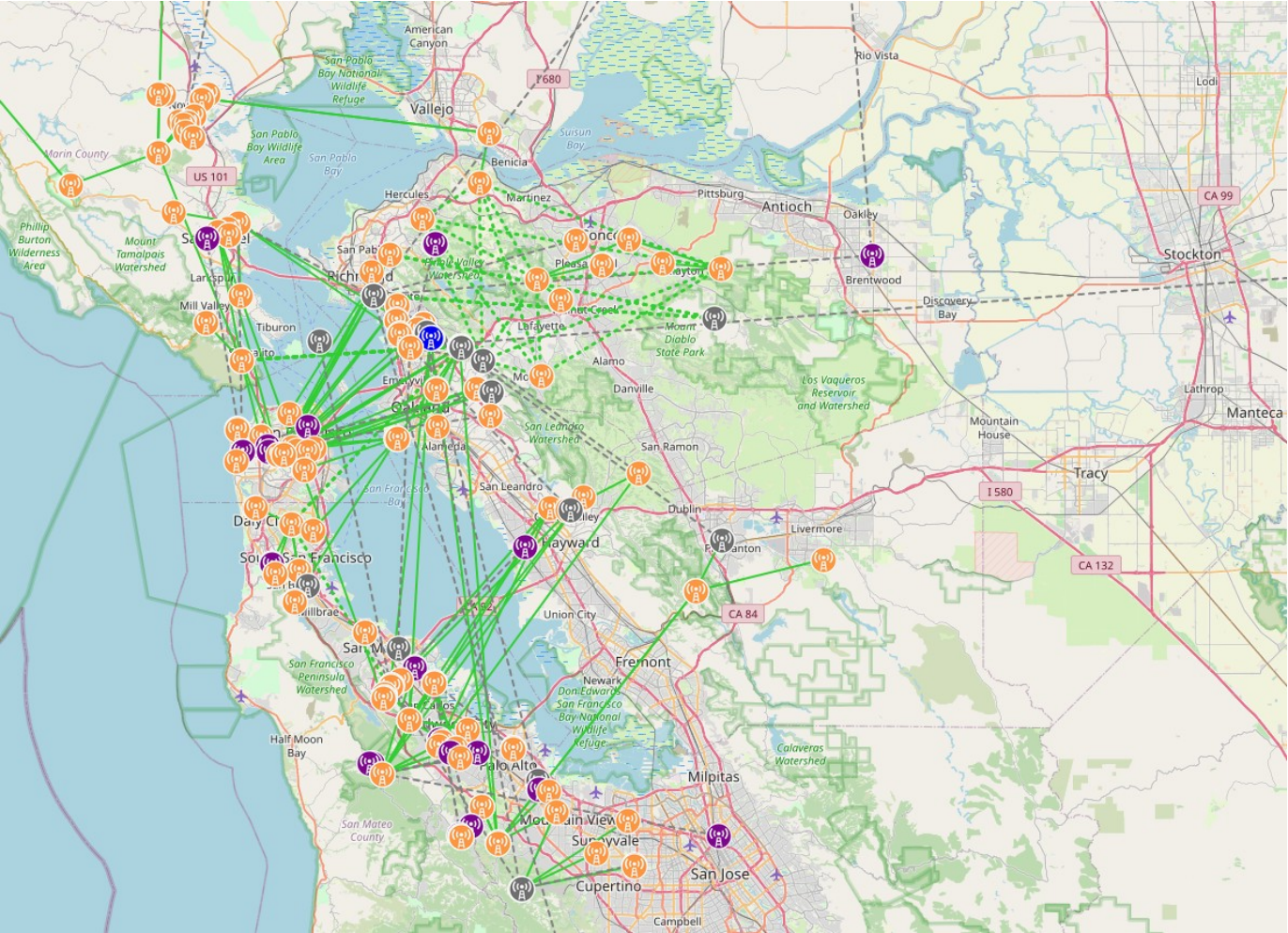
Network map – Yakima, WA



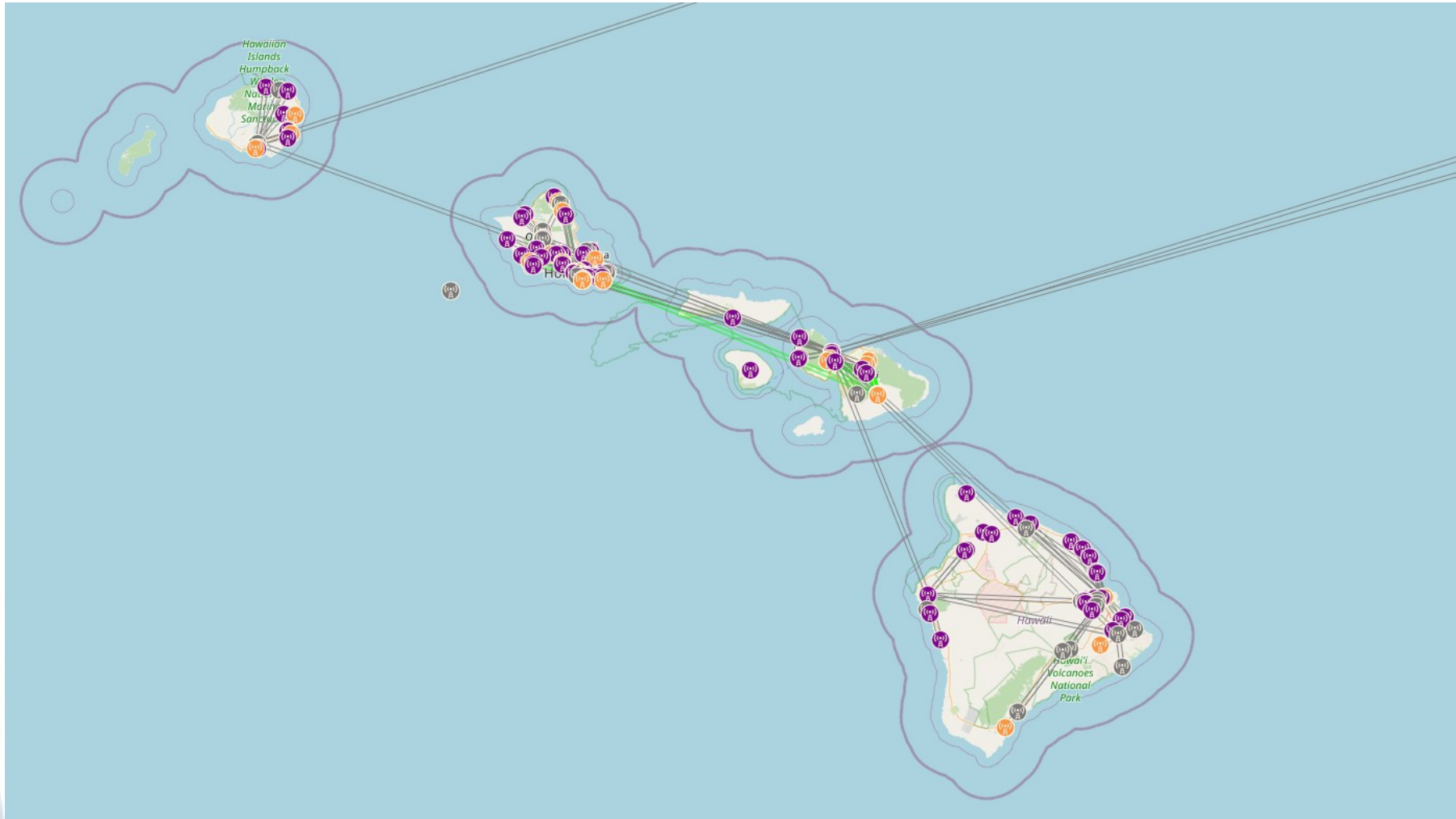
Network map – Salt Lake City, Utah



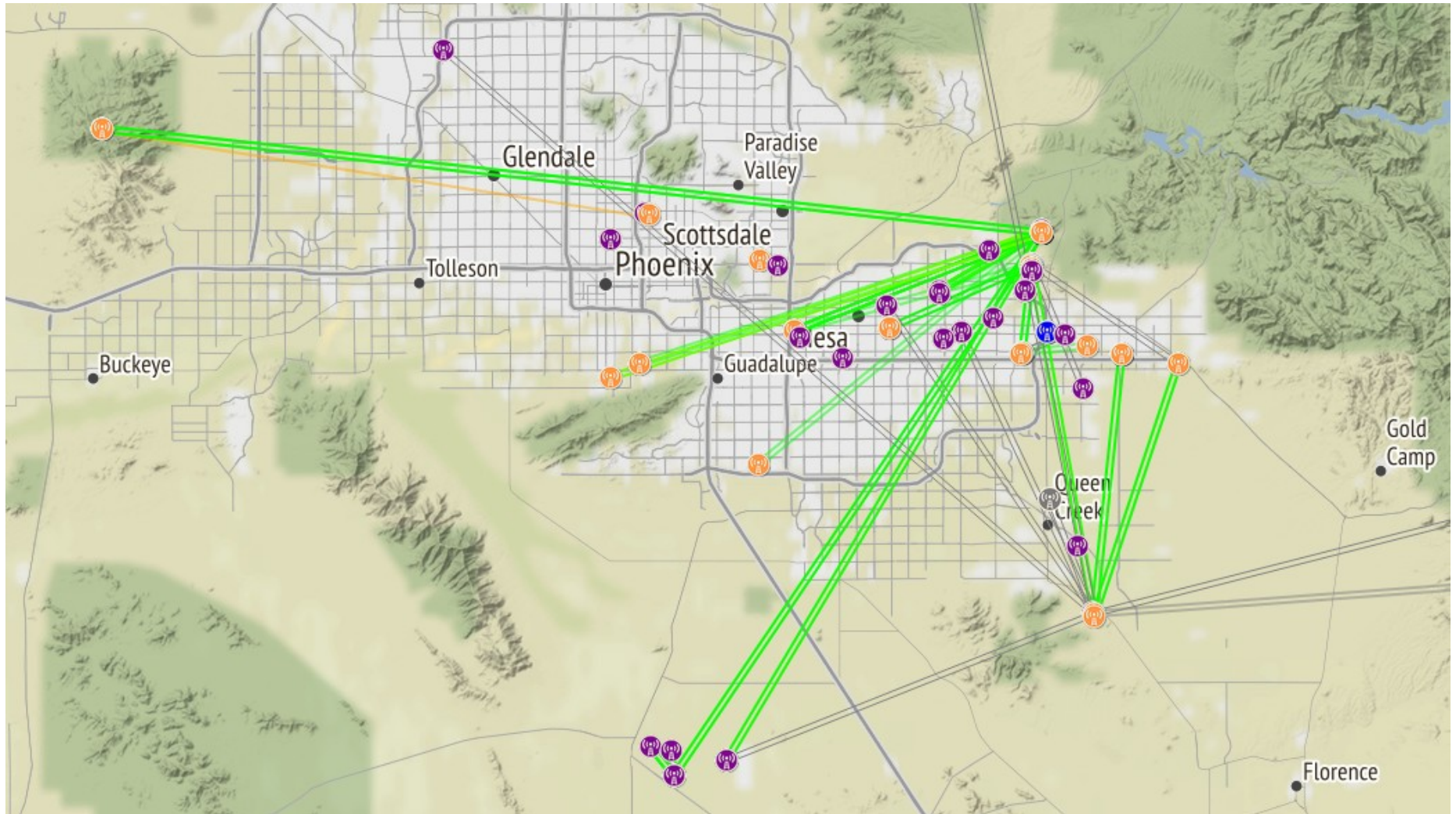
Network map – BAM (Bay Area Mesh) - San Francisco, CA



Network map – Hawaiian Islands

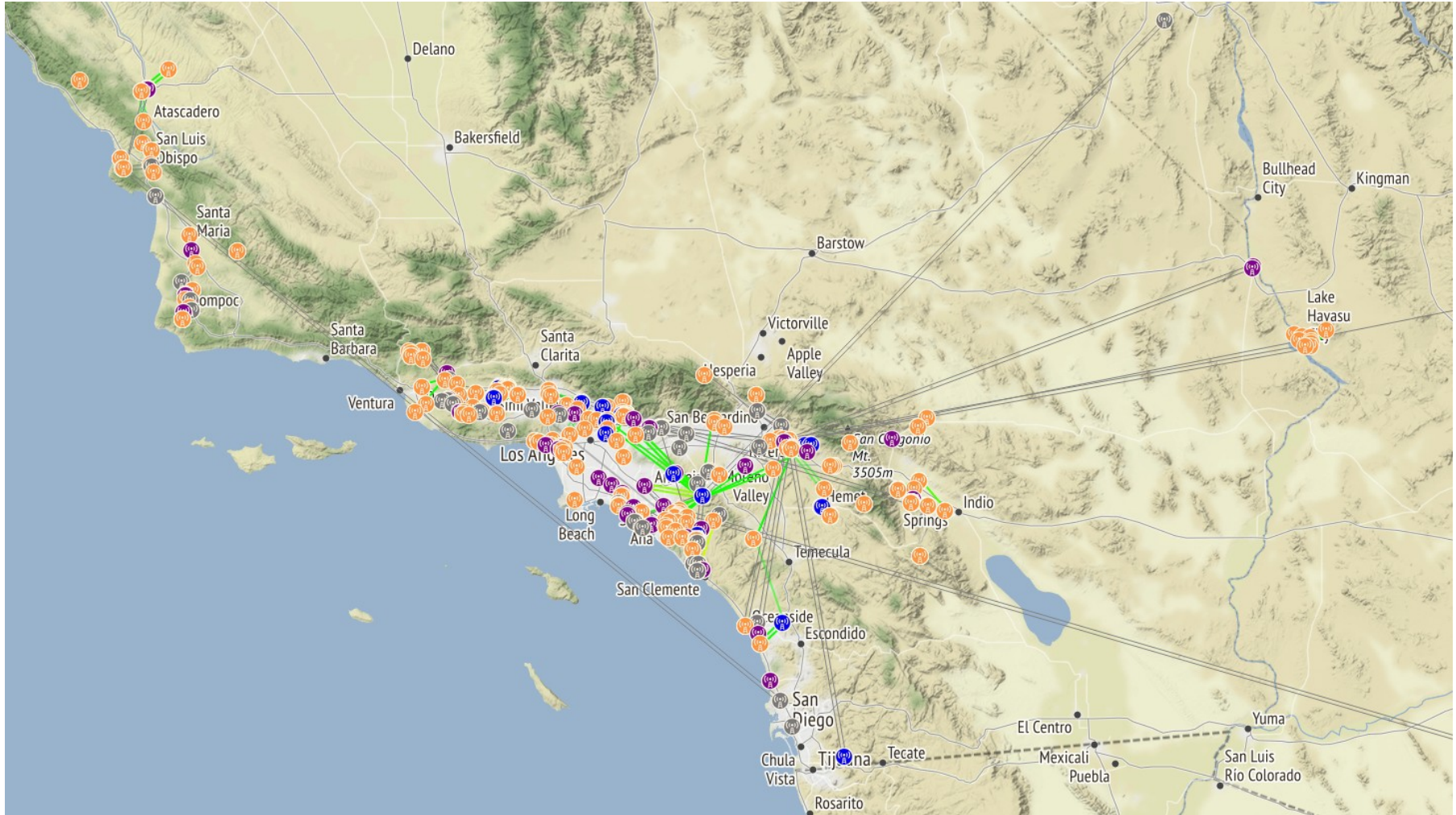


Network map – Phoenix area



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
 - (Mostly) not expensive
 - Mostly designed for outdoor use: weatherproof, use POE for power
 - 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!
 - Typically 600 mW Tx power (split between two channels)
 - 802.11ac gear – better performance than the older 802.11n gear. Recommended for new purchases.

About Modern Access Points/AREDN Nodes

- *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 (**many of these older devices have been sunsetted by OpenWrt, and hence AREDN support for them will cease in the future**)*
 - ▶ *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 Supported Platform Matrix that has flagged supported devices that are no longer recommended for new deployments*
- *Now (1Q23) there's support for some 802.11ac devices. Check AREDN Nightly Build page for latest info.*

Ubiquiti NanoBeam AC 5 gen2
19 dBi gain



Ubiquiti LiteBeam ac Gen2
23 dBi gain



For Longer Distances (or faster throughput)

Ubiquiti PowerBeam AC 500



**MikroTik RBLHGG-5acD,
MikroTik RBLHGG-5acD-XL**



Mikrotik LDF 5ac (Light Dish Feed)

Inexpensive, 9 dBi gain.





- Mikrotik LDF 5 ac (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



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 Lite slides)

Mikrotik hAP AC Lite (no longer recommended)

The Swiss Army Knife of ham networking
A valuable addition to a ham shack network



hAP ac2 & ac3

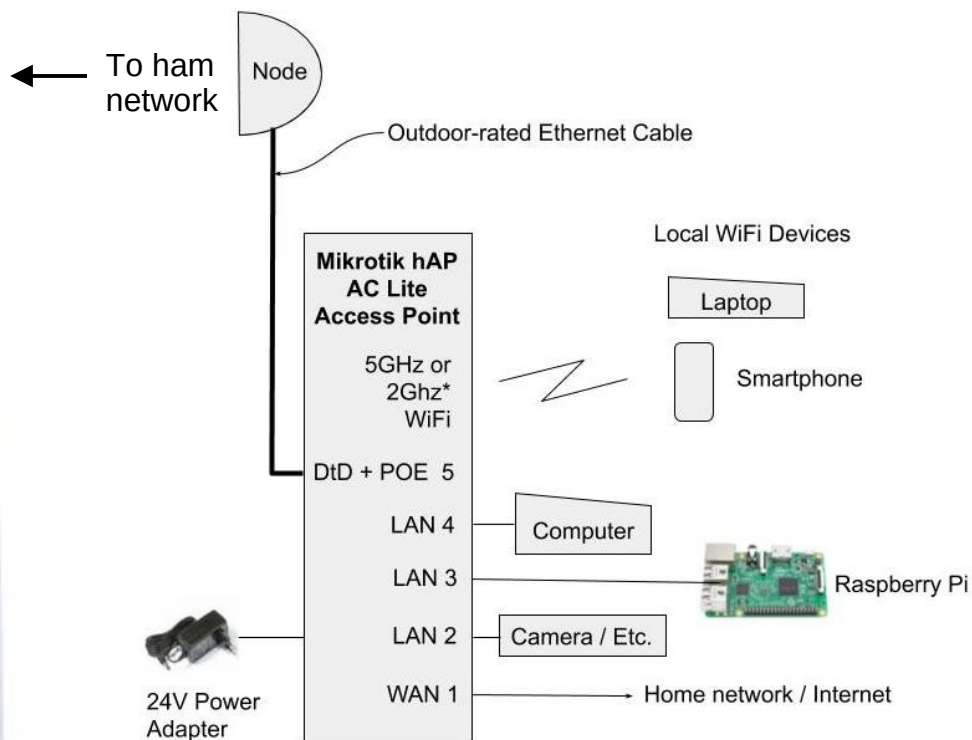
Faster CPU w/4 cores, Gigabit Ethernet ports, more RAM



(No POE on Port 5)



A Mikrotik hAP Ac Lite/2/3 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 a 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 firewall the hamnet off from your home network.

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 is required!



Home Installation example

Ubiquiti Powerbeam for network backbone link;
Ubiquiti Rocket + sector antenna for local redistribution



**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

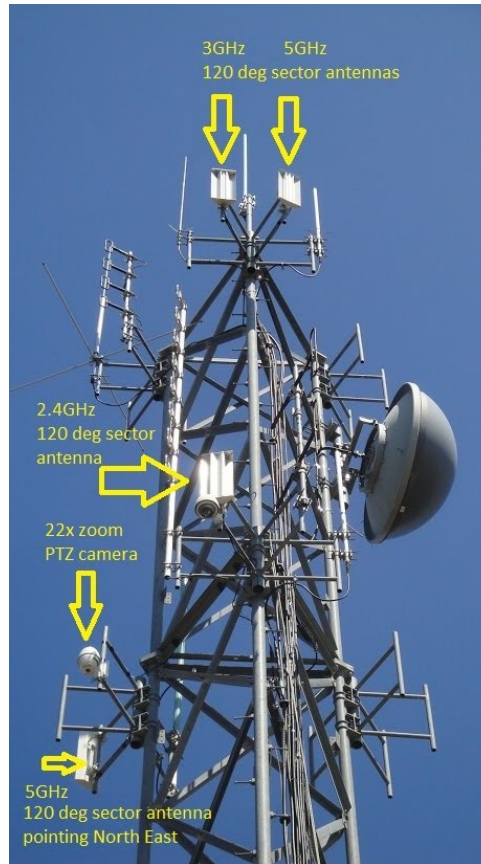


Another medium-sized site (post wind-storm)
(80% FM repeaters, 20% networking) Verdugo Peak, California



Large site (commercial) Pleasants Peak, California

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



Coverage Tools (can two sites 'see' each other?)

- heywhatsthat.com – easy to use
- <https://www.scadacore.com/tools/rf-path/rf-line-of-sight/> - easy
- <https://ispdesign.ui.com/#> - easy to moderate
- Radio Mobile - complex
 - <http://www.ve2dbe.com/english1.html>
- Radiofresnel.com – for calculating Fresnel zones
- Mapping and Distance - <https://www.acscdg.com/>

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 their 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!**

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 4,400 users
- Social media sites: Facebook, Mastodon, Slack, Discord, etc.
- AREDN channel on YouTube
 - * Beware of older HSMM and AREDN YouTube videos; they can be way out of date.