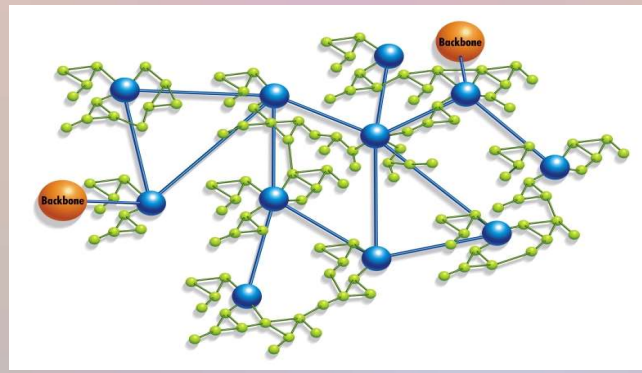
papa system

Southern California's Premier Repeater System

AREDN™
AMATEUR RADIO EMERGENCY DATA NETWORK

The Orange County
Mesh Organization



Presented by

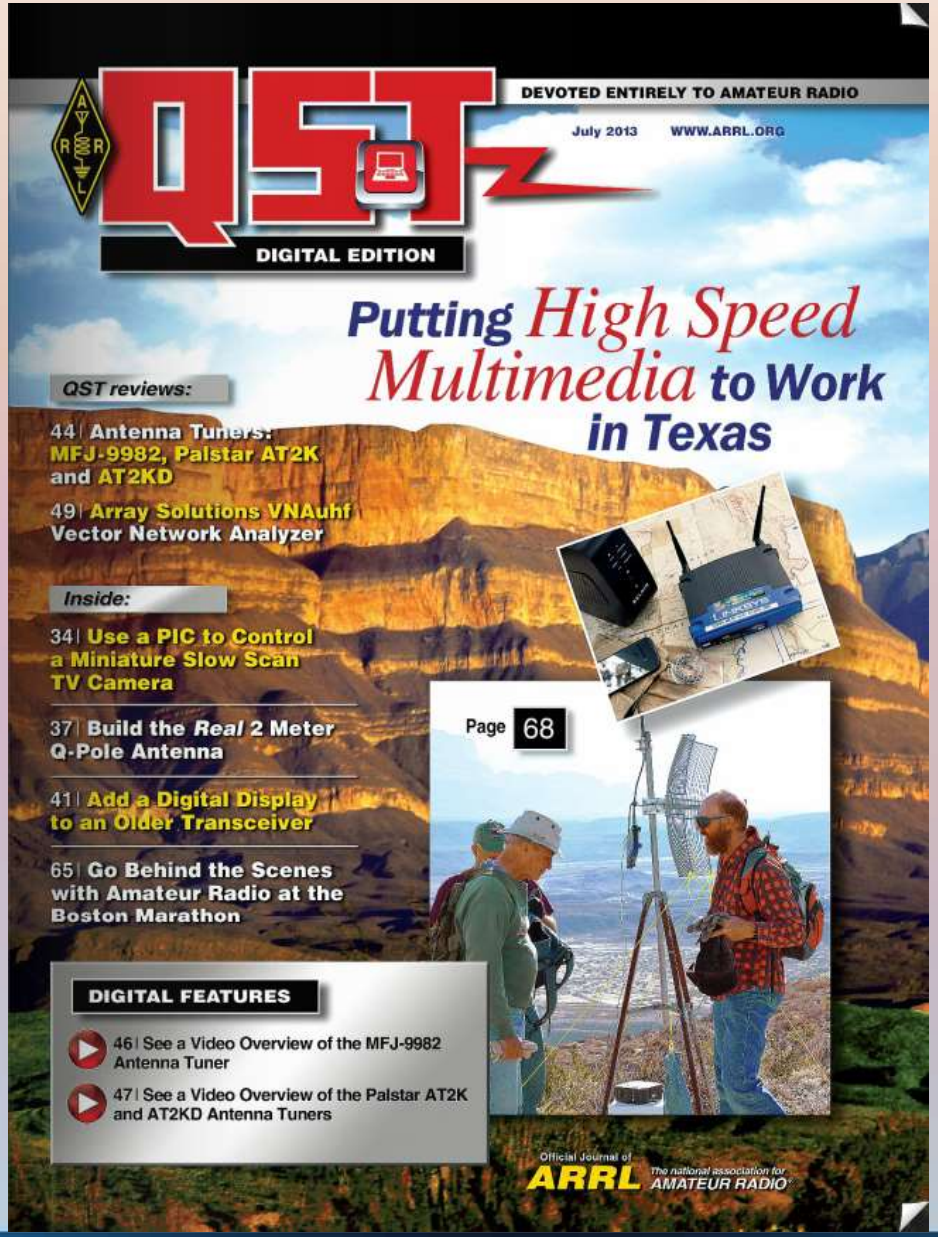
Don Hill, KE6BXT and Joe Ayers, AE6XE

February 23, 2019

First . . . A Little History

- QST Article (July 2013)
- Presented to PAPA on 2015 and 2016
- Talked about putting AREDN nodes at PAPA sites (2017)
- Started turning talk into action 2018
- Status update 2019

Broadband-Hamnet$_{TH}$ in QST – July 2013



Broadband-Hamnet™ in QST – July 2013

A Broadband Ham Network Crosses the Finish Line

A broadband ham network brings long-range video to the Big Bend 50 Ultra Marathon's finish line.

Lynn Jelinski, AG4IU

Big Bend National Park is located north of the Rio Grande River, which separates the United States from Mexico. Big Bend, which is larger than the state of Rhode Island, is a remote and dramatic wilderness located within the harsh Chihuahuan Desert.

Each year in the cool weather of January, Big Bend National Park hosts the Big Bend Ultra Run, a 50 kilometer (31 mile) marathon that is limited to 150 runners to minimize environmental impact. Athletes come from around the world to compete.

The Challenge

To support the marathon, hams from the Big Bend Amateur Radio Club, the Austin Amateur Radio Club and the San Antonio Radio Club established a race control and safety net on 2 meters. The race net had been used during previous races and had proved very effective both for coordination of race activities and runner safety. However, for the spectators, something was missing.

The friends and family of race participants couldn't watch their runners cross the finish line because they were cordoned off in an amphitheater at Rio Grande Village about 10 miles away.

The Solution — a Finish Line Cam

A group of hams from the Austin ARC (Joe Jelinski, KC2KG; Paul Kinney, KD5VRU; Mitch London, KD5HCV, and Alan Russell, KE5DTR) got the idea to deploy a high-speed multimedia mesh (HSMM-MESH) network to broadcast a live video feed from an Internet protocol video camera (similar to those used in security applications) at the finish line for spectators gathered in the remote amphitheater. The network is easy to set up, battery powered and far less expensive than a satellite link.

The Equipment

HSMM-MESH nodes are made from readily available consumer Wi-Fi routers (see **www.hsmm-mesh.org** for model numbers that are supported by the software). No internal hardware modification is needed; it's simple to reprogram the router with free software downloaded from the site. The software converts the standard router to a microwave mesh node. [A mesh node operates within a mesh network. Each node in the mesh network can acquire data from an external device (such as a video camera) and also relay data acquired by other nodes. — *Ed.*] The converted router will still use the factory transmit power of about 80 mW.

As the nodes are powered up, the software enables each node to discover other nodes within range, form network paths and transfer data automatically.

Two of the nodes, the finish line camera node and the Ernst Ridge relay node, were in locations so remote that they didn't have electricity. We chose to use lightweight (6 lb) 12 V battery-powered uninterruptable power supplies (UPS) to power these nodes (see Figure 1).

Figure 1 — The equipment used to establish the HSMM-MESH nodes are the Linksys router, a 12 V battery-powered UPS, signal mirror, compass and leather gloves. [Lynn Jelinski, AG4IU, photo]

Figure 2 — From the left are Mitch, KD5HCV; Joe, KC2KG, and Alan, KE5DTR, who used a compass to aim the antenna and a signal mirror to confirm the orientation. The antenna is secured with guy wires attached to 10 inch steel spikes. The cooler is to keep the battery-powered UPS warm during the night. [Paul Kinney, KD5VRU, photo]

The Amateur Radio Advantage

These routers normally deliver only household distance operation. This is where Amateur Radio comes in. Some of the 802.11B/G (2.4 GHz) channels overlap the Amateur Radio bands. If you hold a Technician class or higher license you may attach an amplifier, antenna or both to the node to increase its useful range. Remember, only the operating software (firmware) in the Wi-Fi router is changed to convert it to a mesh node.

Deploying the Network

Using microwave path analysis software, we determined we needed two nodes, one for a 9.1 mile path (see Figures 2 and 3) and another for a 1.8 mile path. For the 9.1 mile path from Ernst Ridge to the finish line, we used a 24 dB dish antenna at both locations. For the 1.8 mile path to the Rio Grande Village, we used a 12 dB omnidirectional antenna paired with a 12 dB Yagi. With these antennas and clear signal paths, we didn't need an RF amplifier.

Figure 3 — Alan Russell, KE5DTR (L), and Joe, KC2KG, are looking out from the HSMM-MESH node location atop Ernst Ridge to the finish line 9.1 miles away. [Mitch London, KD5HCV, photo]

Figure 4 — Paul Kinney, KD5VRU, adjusting the video display and dealing with the bright Texas sun. [Joe Jelinski, KC2KG, photo]

Network Performance

Thanks to careful placement of the nodes, good antennas and the low RF noise floor at Big Bend National Park, we were able to get 100% copy. We placed backup batteries at each remote node in case we needed them, but the original batteries lasted for the entire 10 hours of the race. The batteries powering the video camera lasted for 6 hours and needed to be changed during the race.

Prior Planning and Testing Payoff

Our group spent many of our Digital Wednesday meetings planning the operation. We studied topographical maps, tested the nodes and checked the cold-temperature performance of the batteries. Having planned the antenna locations, we performed a microwave path analysis of the terrain to see how reliable the paths would be.

Once at Big Bend we validated our planning with on-site testing. We set up the network, checked antenna stability and battery integrity 2 days prior to the event. In preparation for the event each of us had climbed Ernst Ridge with heavy backpacks at least three times, clawing for handholds in the rocks while hoping the temperature was too cold for scorpions and rattlesnakes. Each ascent was the equivalent of climbing 400 stairs.

Hot Wash-up

It was dark by the time the final runner, who was by then a walker, hobbled across the finish line. Under the light of the stars we reviewed what went well and what could be improved.

The major glitch of the event was that we underestimated the intensity of the setting Texas sun. It was so bright that it overpowered the video projector. Despite our having erected a canopy over the screen, using a projection screen with a highly reflective surface and a high-powered projector, the finish line video projection was hard to see (see Figure 4). Next year we will use a TV screen or a CRT to display the live video feed.

Next Year — Audience Cam

Spectators loved seeing their runners cross the finish line, but the runners themselves didn't hear the cheers or share in their exhilaration. Next year we plan to place a second video camera in the audience — an "audience cam" — so we can provide a live video feed to the athletes at the wilderness finish line. HSMM-MESH is up to the task!

Joe Jelinski, KC2KG; Paul Kinney, KD5VRU; Mitch Loden, KD5HCV, and Alan Russell, KE5DTR, contributed to this article.

Lynn Jelinski, AG4IU, an ARRL member, was first licensed in 2000. Lynn and her spouse, Joe, KC2KG, were members of the East Coast Waterway Net during their 11 years operating maritime mobile. Lynn helps universities write grants for research funding. Lynn and Joe can be contacted at 6406 Hopkins Dr, Austin, TX 78734, **kc2kg@earthlink.net**.

VOTE
Did you enjoy this article? Cast your vote at www.arrl.org/cover-plaque-poll

Overview

- What is a AREDN Mesh Network?
- How is an AREDN Mesh Node differ from Wi-Fi Router?
- Websites (AREDNMESH.org and OCMESH.org)
- Some of the Major Nodes in Orange County
- New Nodes at PAPA sites

What is a AREDN Mesh Network

- Was known as High Speed Multimedia (HSMM-MESH)
- Take an inexpensive off-the-shelf wi-fi device...
- Install ham-developed firmware and...
- We can easily create high-speed networks

- Networks are self-discovering and self-configuring
- Hams don't need to be IT personnel to create networks
- With high-gain antennas, range of miles
- Limitation...line of sight range

Mesh Node vs Wi-Fi Router

Wi-Fi or not Wi-Fi?

Wi-Fi

RF looks for wireless clients

AREDN Mesh Node

RF looks for other MESH nodes

AREDNMESH.org

Amateur Radio Emergency Data Network

AREDN
AMATEUR RADIO EMERGENCY DATA NETWORK

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Alerts

Do not flash a Ubiquiti device that is running, or has been running, airOS version 5.6.2 or higher with AREDN firmware. We have become aware of a change that may be incompatible with current firmware images. We are looking into the concerns raised and will post more details as they are determined. We have developed the following utility to help determine if your device is compatible. Download the AREDN U-Boot Test Setup Program. Requires Windows 7 or higher and Microsoft .NET Framework 4.5.

News

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OCMESH.org

The Orange County Mesh Organization

Orange County Mesh Organization

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The Orange County (Broadband-Hamnet/AREDN) Mesh Organization

Who is the Orange County (Broadband-Hamnet/AREDN) Mesh Organization?

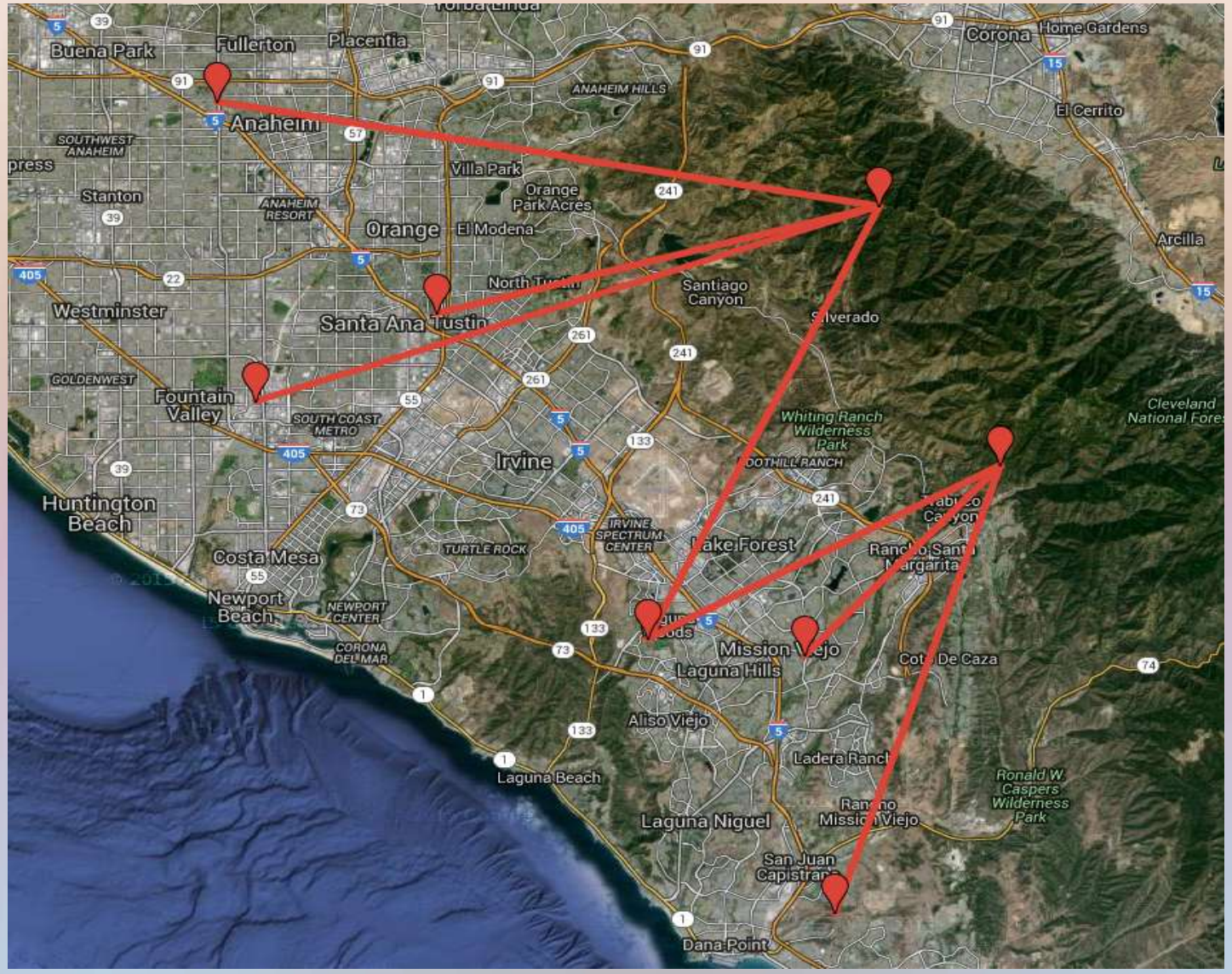
The Orange County Broadband-Hamnet/AREDN Mesh Organization is a group of Amateur Radio Operators (HAMs) who are working together to establish a synergistic TCP/IP based mesh of nodes in the Orange County (California) area and neighboring counties using commercial hardware and open source software (firmware) developed by the Broadband-Hamnet and AREDN development

In The News

Laguna Woods Village installs three mesh nodes on gate 14 tower:
Building a safety net

Mesh networking for the Swallows Day Parade in San

Major Nodes in Orange County

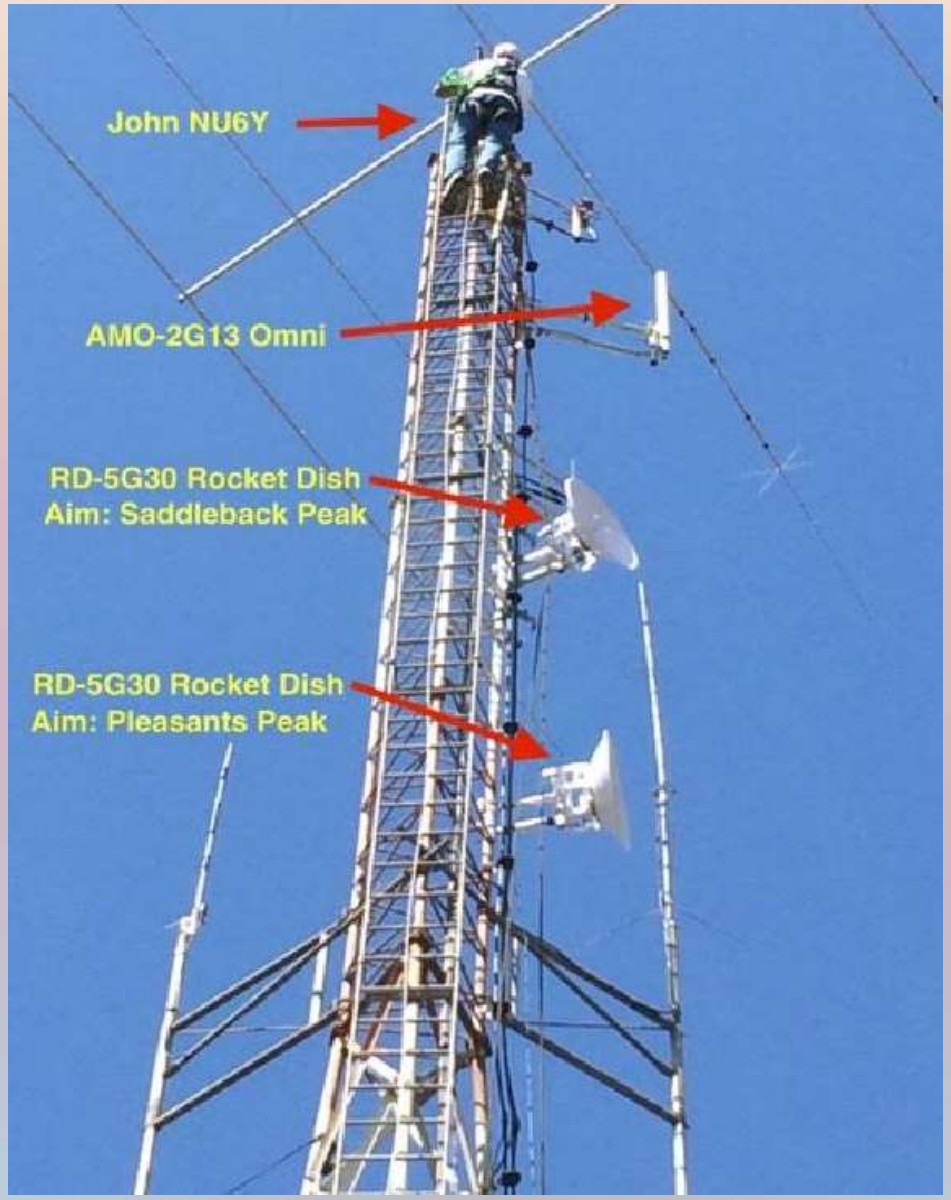


Saddleback 2.4 GHz, 3 GHz, and 5 GHz

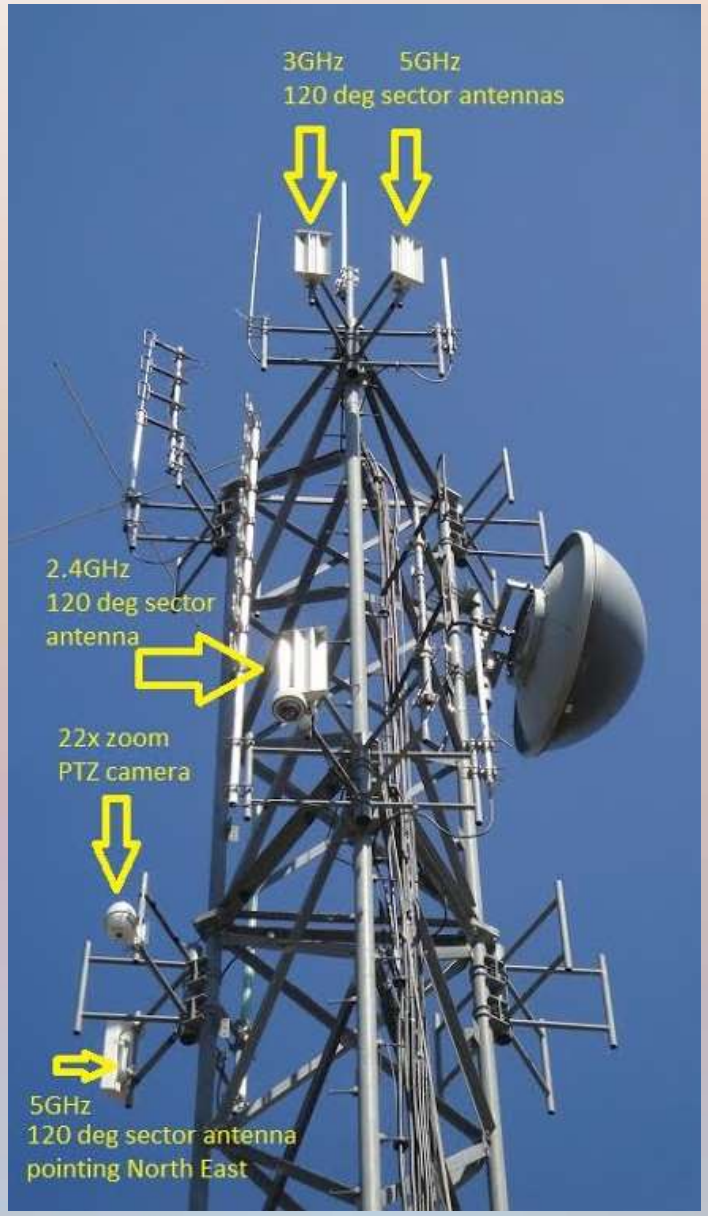
Saddleback 2.4 GHz, 3 GHz, and 5 GHz

KE6BXT-M5R-68-143-86 (5GHz node)
KE6BXT-MVCHR-Bullet-grid-165
(Locaded on the roof of Mission Viejo City Hall)

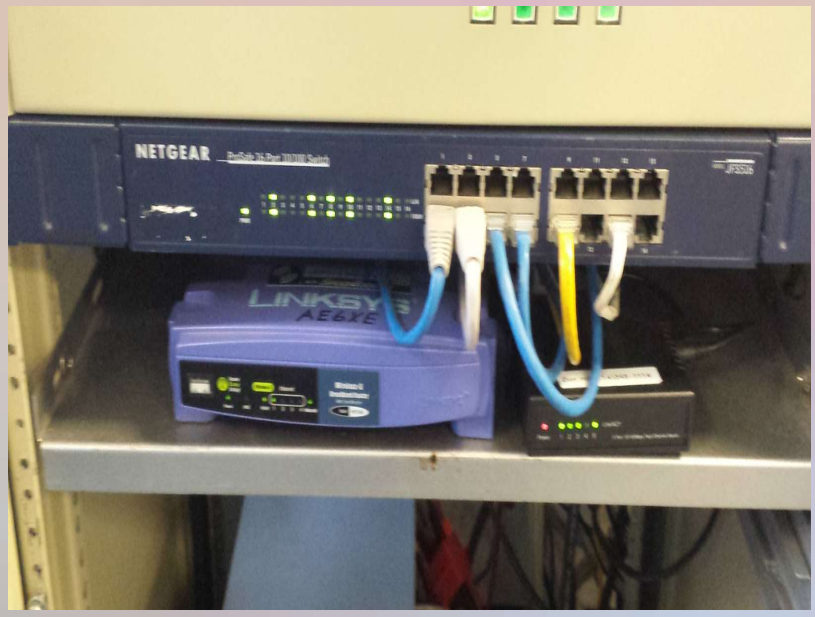
Laguna Woods



Pleasants Peak



Anaheim Ham Radio Outlet (HRO)



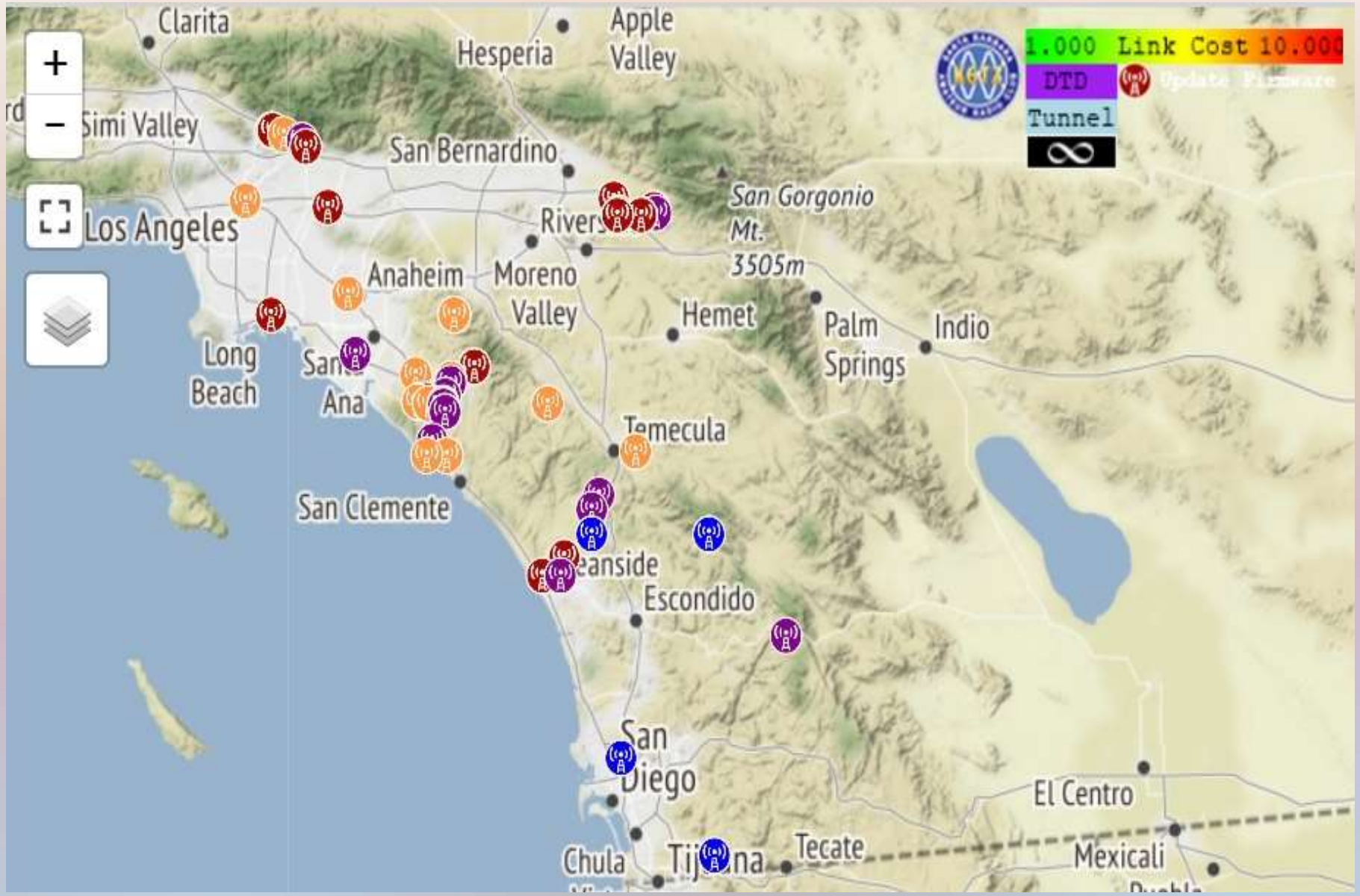
AREDN nodes at PAPA Sites

Toro Peak and Edom Hill

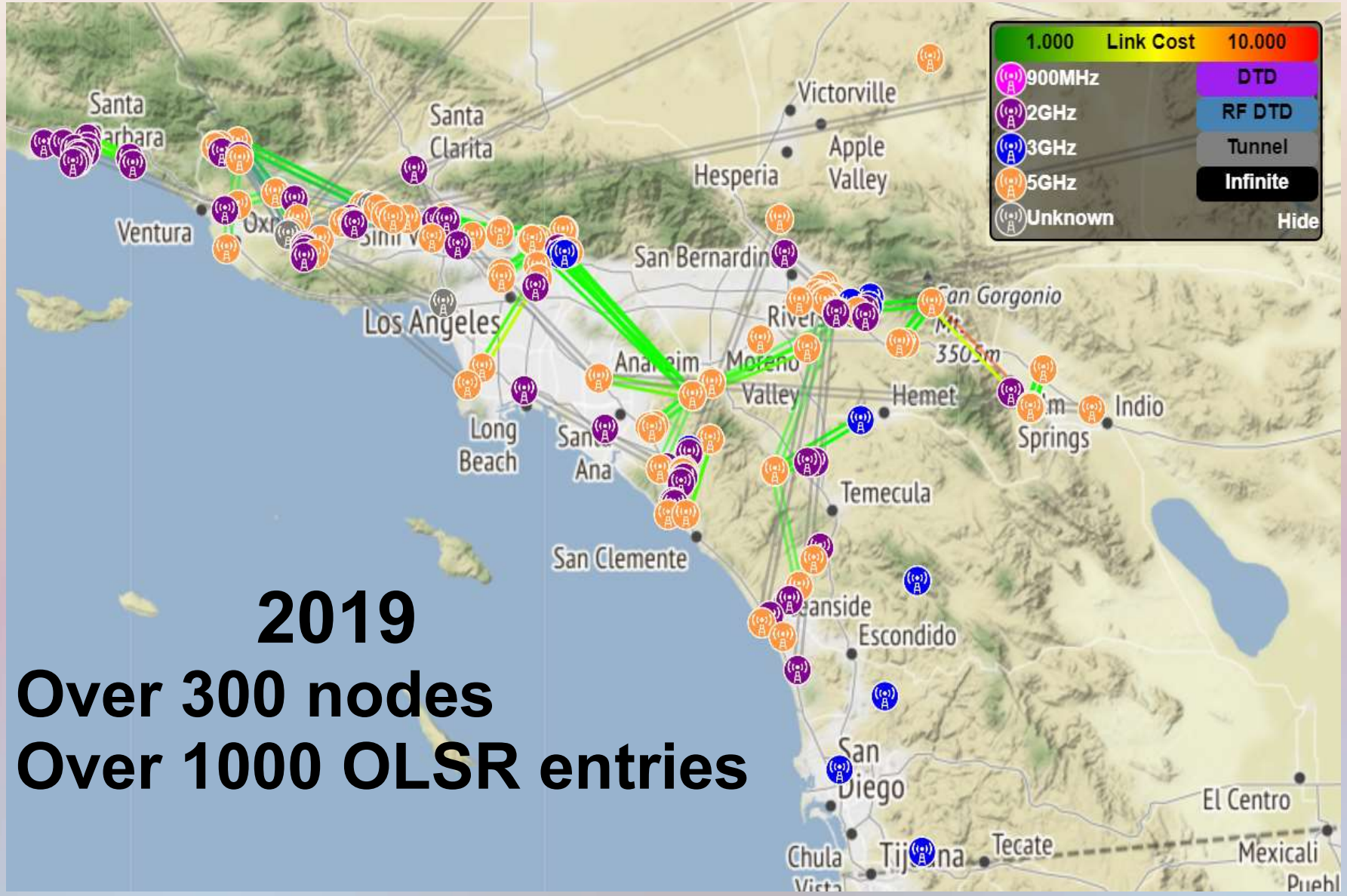
Toro Peak

Edom Hill

Orange County (CA) “real-time” Map



Node Map



2019

Over 300 nodes

Over 1000 OLSR entries

Overview

- Setting up a Mesh Node (Hardware, Firmware, Settings)
- What services can you add to a MESH network?
- Connecting a HAM Radio Mesh Network to the Internet.
- Internet Tunneling.
- Demos
- Q & A

Hardware Choices

2013

Linksys WRT54G

2019

Ubiquiti	TP-Link	Mikrotik
AirGrid	CPE (v1.0)	LHG (Lite Head Grid)
AirRouter	CPE (v1.1)	LHG HP/XL
AirRouter HP	CPE (v2.0)	Basebox
Bullet	CPE210	hAP AC Lite (dual band)
Bullet Titanium	CPE220	LDF (Lite Dish Feed)
Bullet	CPE610	
NanoBeam		
NanoBridge		
NanoStation Loco		
NanoStation		
PicoStation		
PowerBeam		
PowerBridge		
Rocket		
Rocket Titanium		

Supported Hardware

Linksys:

- WRT54G*

Ubiquiti

- Nanostation Loco
- Nanostation
- NanoBridge
- Rocket
- Bullet
- Airgrid

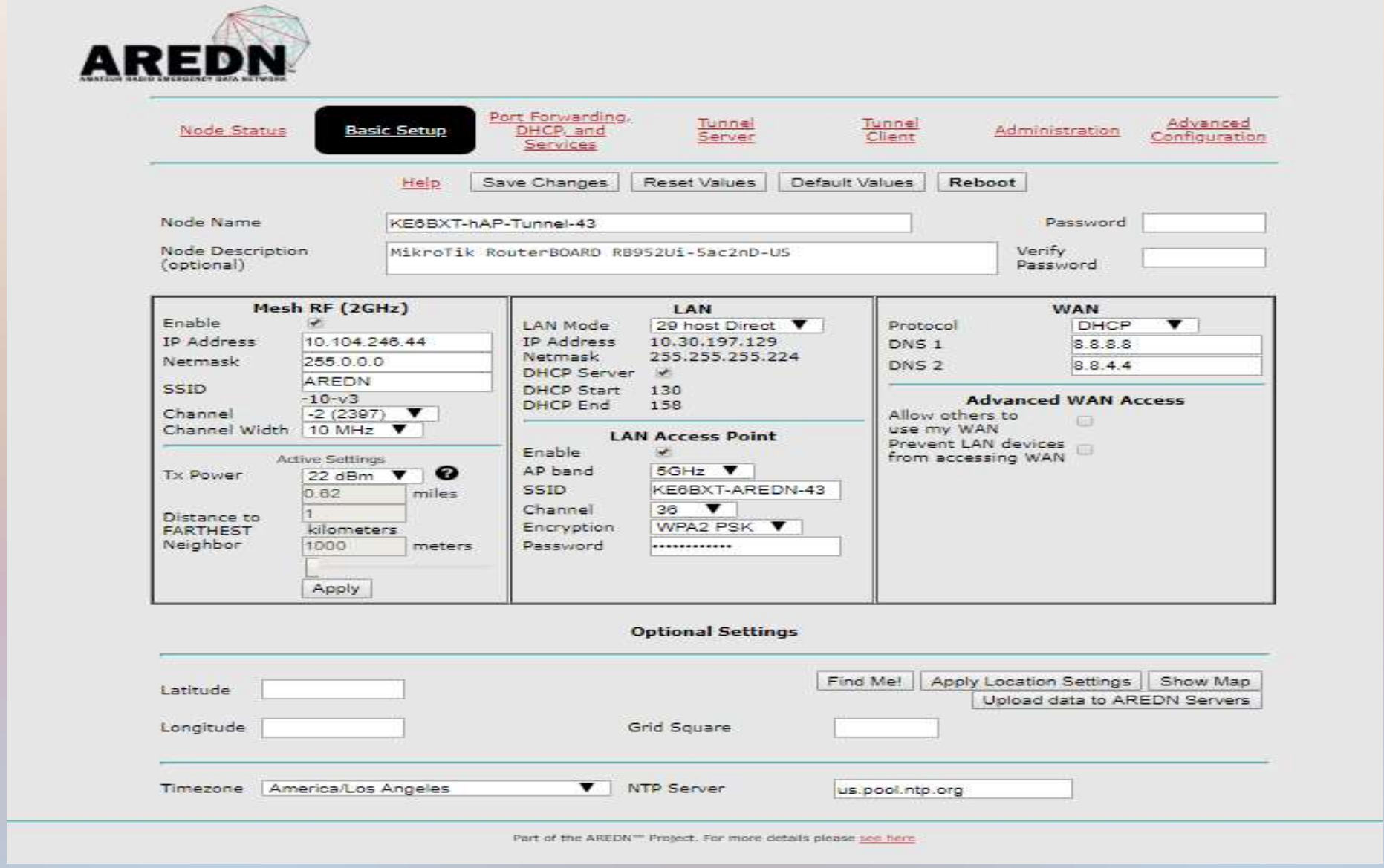
Supported Hardware

- Rockt Dish
- Airmax Basestation

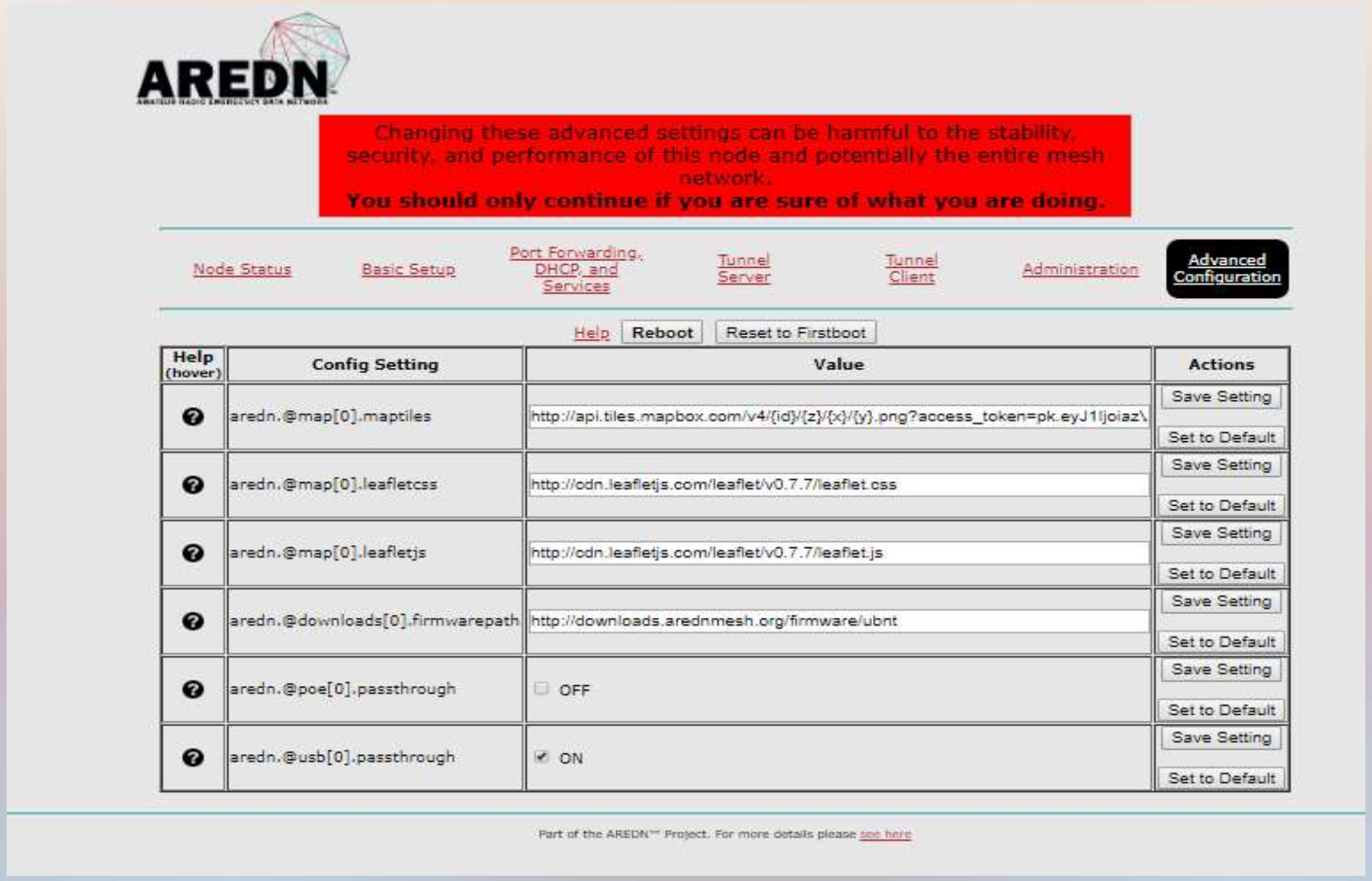
  Sector antenna

  (90 deg, 120 deg)
- MIMO Omni
- Non-MIMO Omni or Grid Dish

New Firmware Settings



More New Firmware options



Orange County Mesh Organization

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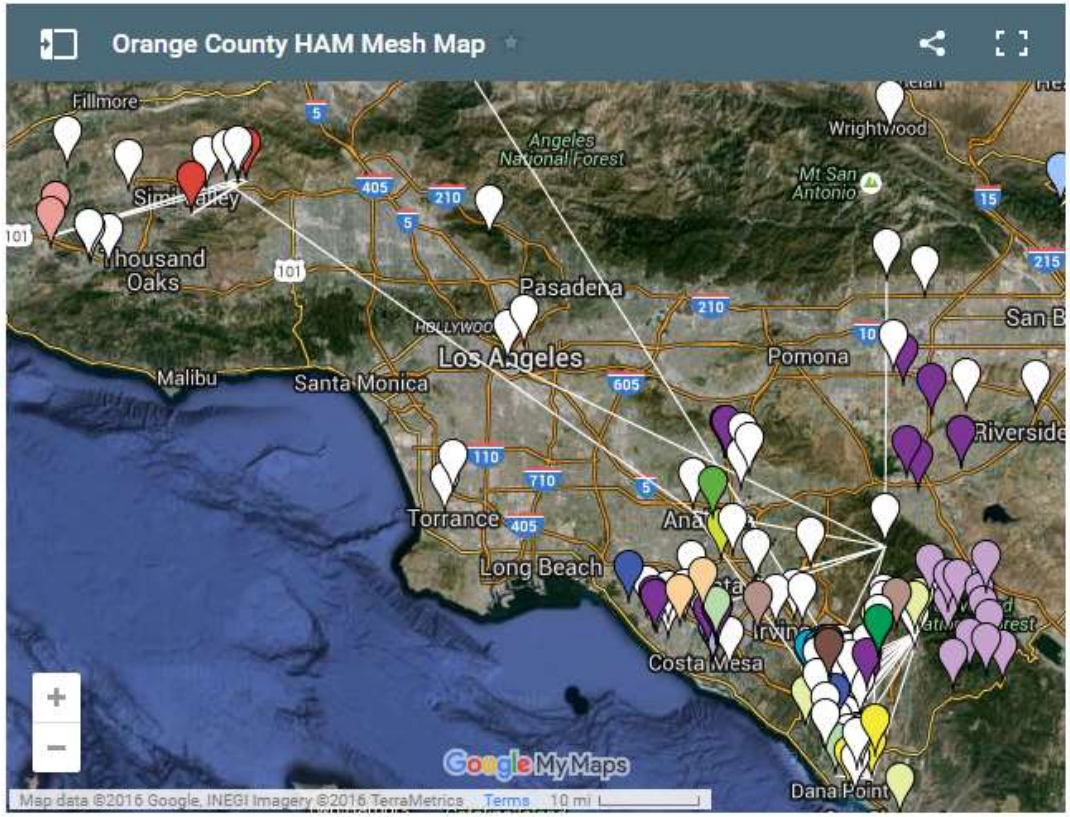
More Nodes in Orange County



Pop-out map

Get on the Orange County Mesh Map

This map shows locations we are looking at because a HAM has indicated that they have an interest in mesh networking or because a node or nodes have been installed at that location. If you you are interested in installing a mesh node in Orange County, please get in touch with either Don Hill or Joe Ayers and we will add

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Hardware

Why we do not recommend using the Linksys WRT54G Routers for HAM Mesh Networking

Bullet/Bullet-Ti					
BM2HP	2.4 GHz	100+ Mbps	600mw	28 dBm	2412-2462 MHz
BM2-Ti	2.4 GHz	100+ Mbps	600mw	28 dBm	412-2462 MHz
BM5HP	5 GHz	100+ Mbps	600mw	25 dBm	5170-5825 MHz*
BM5-Ti	5 GHz	100+ Mbps	600mw	25 dBm	5170-5825 MHz*

Source: bm_ds.web.pdf and BulletM_Ti_DS.pdf
* Only 5725 – 5850 MHz is supported in the USA
Note: dBm refers to output power

AirGrid M					

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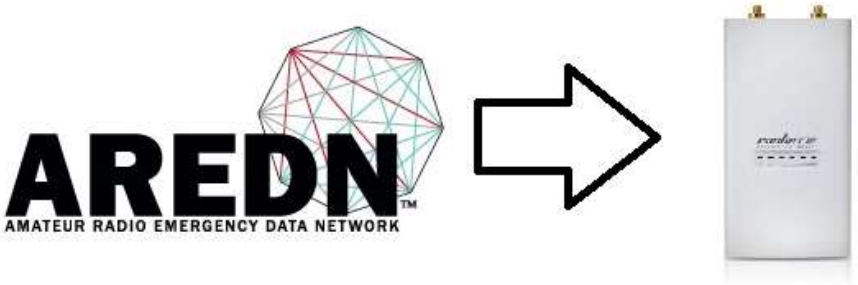
Software (Firmware)



Turning your Ubiquiti radio into an AREDN mesh node

All of the instructions on how to download and load the AREDN firmware are on the AREDN website. Rather than repeating the steps here, we will refer you to **http://AREDN.org**

Go to the menu at the top of the page and mouse over SOFTWARE.

Below **SOFTWARE** is **DOWNLOAD** that allows you do download the firmware from the web site and store it on your computer.

Below **DOWNLOAD** is **INSALLATION** that walks you through verifying that your hardware will support the AREDN firmware, and then upload the firmware from your computer to the Ubiquiti radio.

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- INSTALLATION
- NETWORK SWITCH CONFIGS

Software

Before flashi…at is running or has been running AirOS version 5.6, please run the AREDN U-Boot Test program bel… firmware load or upgrade.

We have developed the following utility to help you determine if your device is compatible, as well as being able to take a BACKUP of your node's critical partitions.

Download and run the AREDN U-Boot Test Setup Program. If the test results in a "GOOD/GOOD" result, then you may proceed to load the appropriate AREDN firmware onto it.

If the test results are "BAD," then you should do the following:

1. Backup your device partitions using the AREDN U-Boot Test program.
2. Use the AirOS GUI to downgrade to AirOS v5.5.x.
3. Re-run the AREDN U-Boot Test program and look for a "GOOD/GOOD" test.
4. If "GOOD/GOOD", you can safely use the AirOS GUI to install the AREDN firmware.

Requires Windows 7 or higher and Microsoft .NET Framework 4.5.

Notes for Over the Air Upgrade are below

Use this "factory" file when loading from AirOS or TFTP
Use this "sysupgrade" file when loading from AREDN (or BBHN)

Use this "factory" file when loading from AirOS or TFTP Use this "sysupgrade" file when loading from AREDN (or BBHN)		
Latest Stable version is: 3.15.1.0		
AREDN™ Firmware for Ubiquiti		
Bullet M2 Bullet M5 Bullet M2 Titanium Bullet M5 Titanium NanoStation Loco M2 NanoStation Loco M5 (XM) NanoStation Loco M9 NanoBridge M2 NanoBridge M5 NanoBridge M9 AirGrid M2 AirGrid M5 PicoStation M2	factory md5sum: 284883fd8158466c0322735a0568db18 Size: 4.4M	sysupgrade md5sum: 78c38e1d8d01240f70db069d59866dc6 Size: 4.4M
NanoStation M2 NanoStation M3 NanoStation M5 (XM) NanoBridge M3	factory md5sum: 2bf57572e27cd6a328371af1885e73e4 Size: 4.4M	sysupgrade md5sum: 90a07696015a3f7c52dfd2ad085d3c02 Size: 4.4M
Rocket M2 Rocket M3 Rocket M5 Rocket M9	factory md5sum: 83850ee1f7cccef92a3938b286bcc3ec Size: 4.4M	sysupgrade md5sum: 790d25a1e6d0a04d5168dbd2840ffd8a Size: 4.4M
NanoStation M5 (XW)	factory md5sum: 3d80d30764c65d6e60ca67289cb1b94c Size: 4.4M	sysupgrade md5sum: 50cc9e479bb24aaf500e6cf7ba698b59 Size: 4.4M
AREDN™ Firmware for TP-Link		
CPE210 CPE510	factory md5sum: 77598cd1c8b53beeb36eddb5867bf5b1 Size: 4.5M	sysupgrade md5sum: 2db1d122a51f9d3189a017213ec56ea1 Size: 4.9M
Patches		
Over The Air Upgrade support for AREDN v3.0.2. To be used	V3.0.2 OTA Support Final	

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Basic Setup

Configuring your node to attach to another node in the OC Meah

Now that you have flashed the AREDN firmware on your new Ubiquiti or TP-Link node there are a few settings you need to make (in addition to naming your node with your callsign).

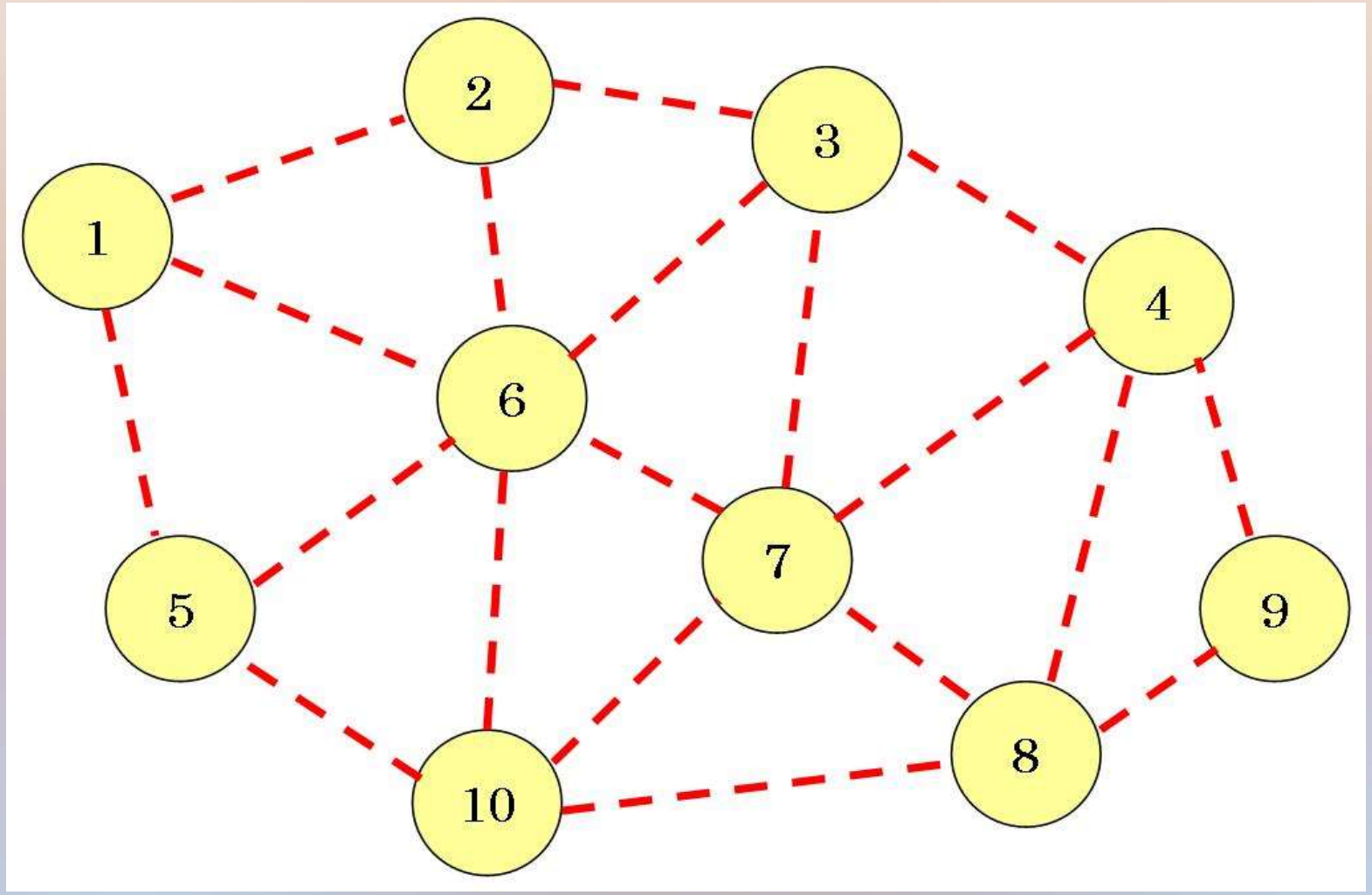
Clicking on the Setup button should take you to the Basic Setup page. Looking at the OC Mesh map determine which node you want to connect to and enter the following information in the WiFi section.

After you have entered your SSID, Channel, and Channel Width, click on the **Save Settings** button and, when prompted, click on the **Reboot** button.

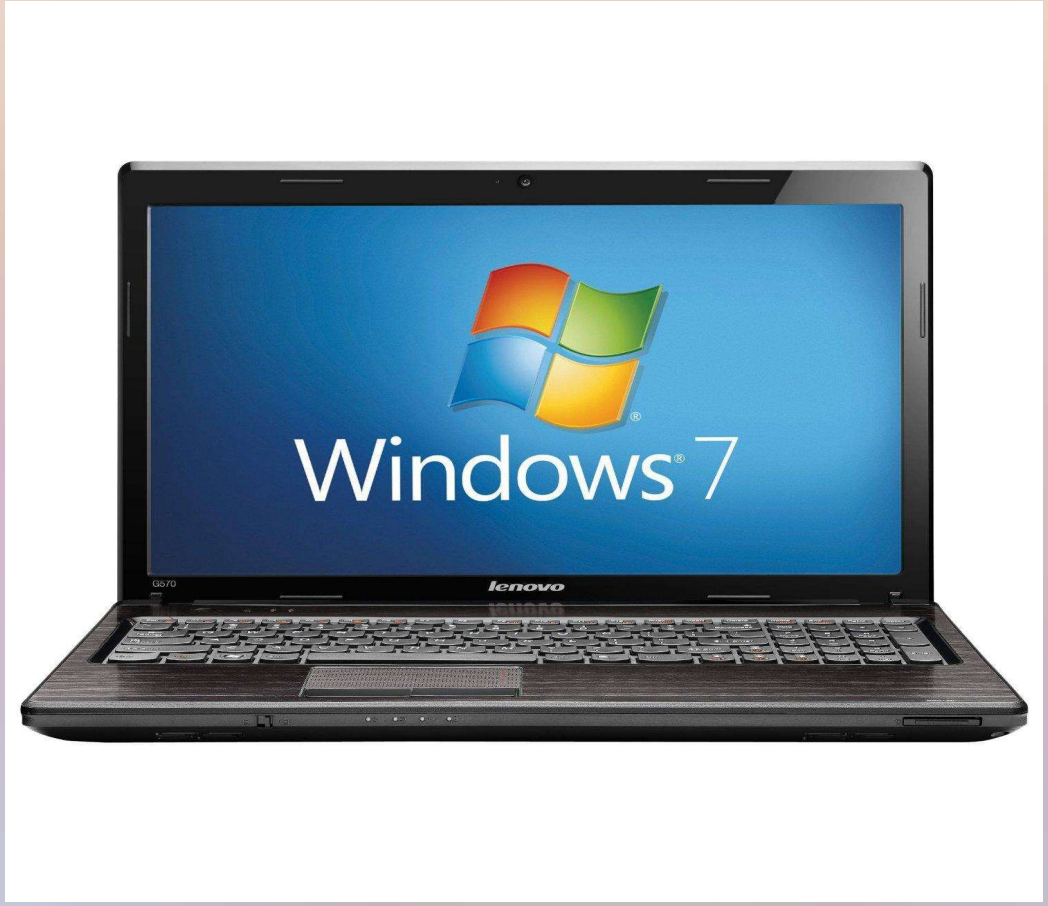
2.4 GHz nodes

Node Name	SSID	Channel	Chanel Width
W6ARH-M2HP-24A43C	BroadbandHamnet	-2 (2397)	10 MHz
AE6XE-PleasantsPk-RM2	BroadbandHamnet	-2 (2397)	10 MHz
AE6XE-Saddleback-RM2	BroadbandHamnet	-2 (2397)	10 MHz
KE6BXT-MVCH-M2B-Grid-140-228-165	BroadbandHamnet	-2 (2397)	10 MHz
KE6BXT-MVCH-M2R-NORTH-122-48-97	BroadbandHamnet	-2 (2397)	10 MHz
KE6BXT-MVCH-M2R-SOUTH-62-84-116	BroadbandHamnet	-2 (2397)	10 MHz
KE6BXT-M2NB-RedCross	BroadbandHamnet	-2 (2397)	10 MHz
KE6BXT-W6HRO-M2R-12-238-64	BroadbandHamnet	-2 (2397)	10 MHz
KE6BXT-W6HRO-M2R-RDISH	BroadbandHamnet	-2 (2397)	10 MHz

So you have a MESH network... What can you do with it???

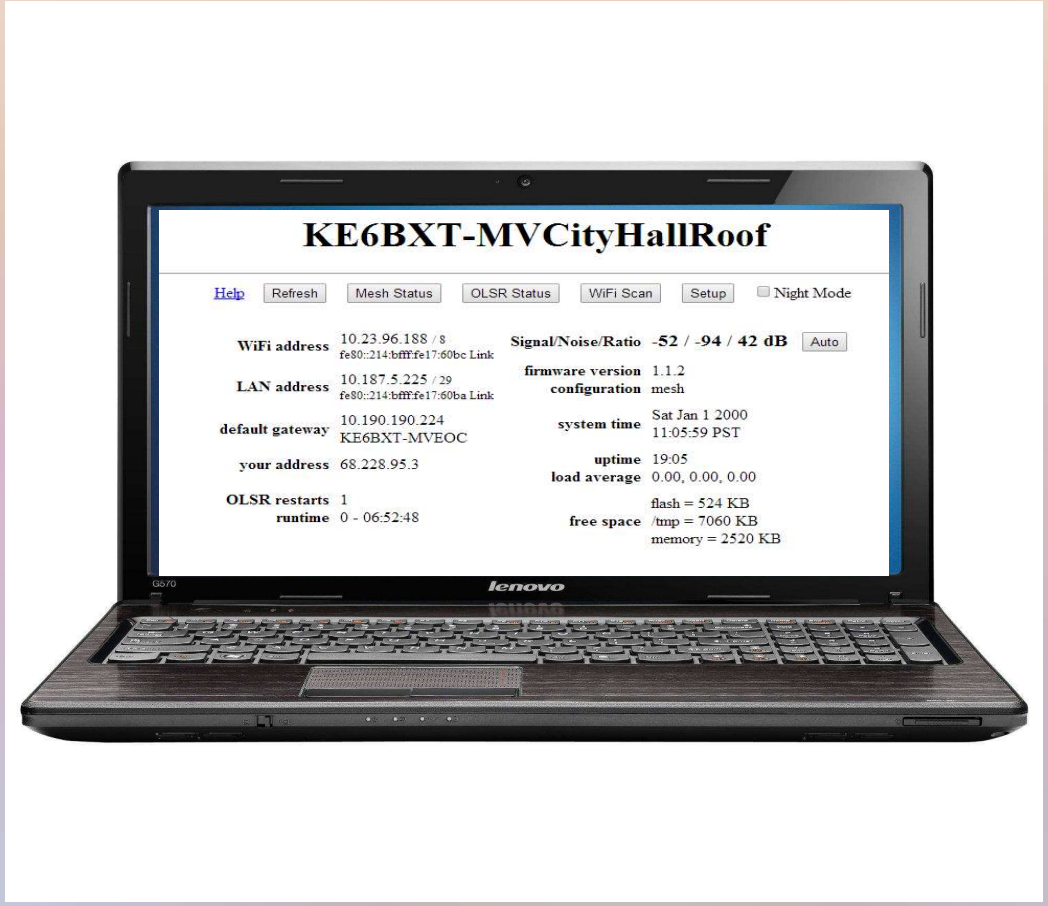


First, you will need a Computer!
(To load the AREDN firmware)

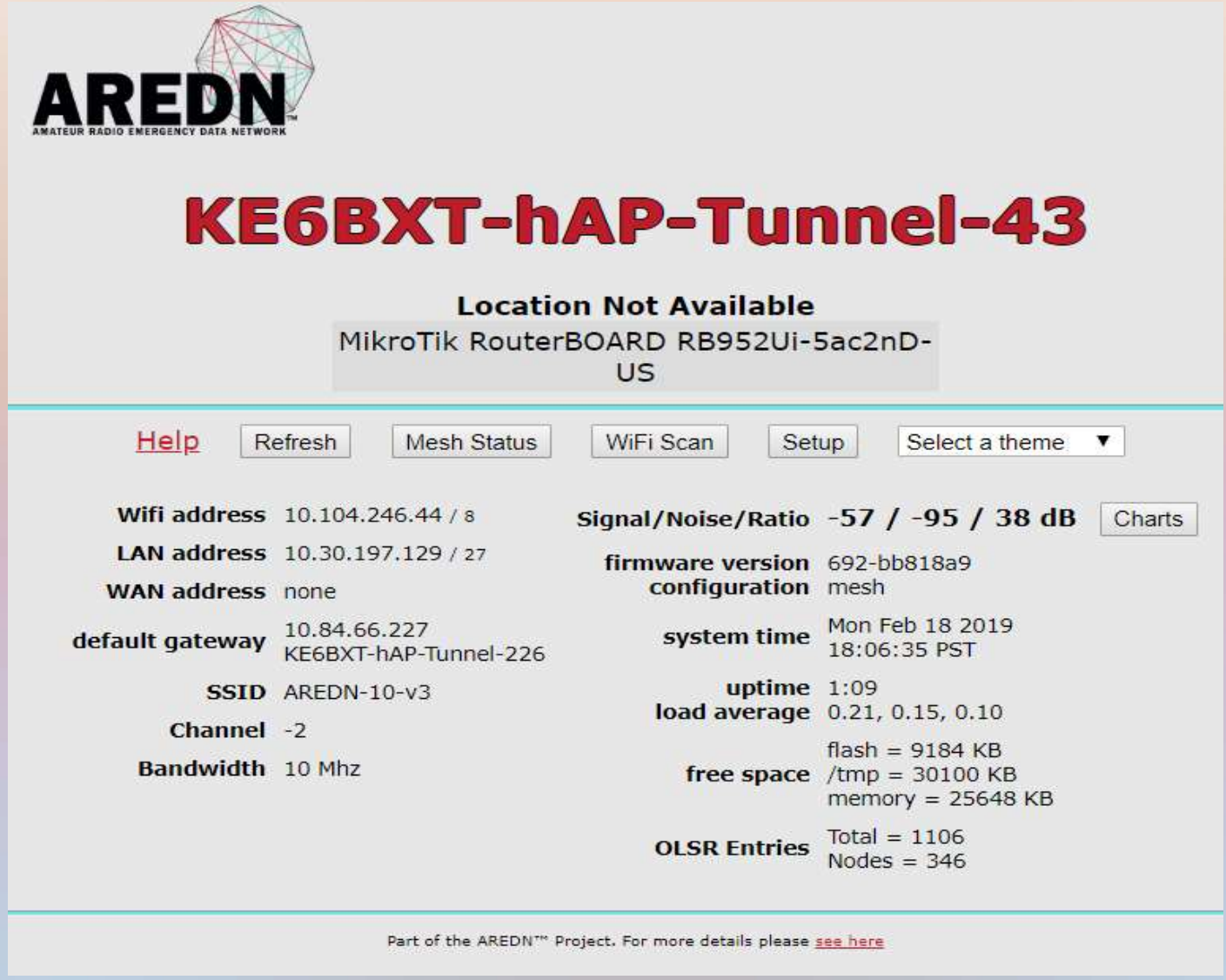


First, you will need a Computer!

So you can check the Node/Mesh status.



Node Status


AREDN
AMATEUR RADIO EMERGENCY DATA NETWORK
KE6BXT-hAP-Tunnel-43
Location Not Available
MikroTik RouterBOARD RB952Ui-5ac2nD-US
Help
Refresh
Mesh Status
WiFi Scan
Setup
Select a theme
Wifi address 10.104.246.44 / 8
LAN address 10.30.197.129 / 27
WAN address none
default gateway 10.84.66.227 KE6BXT-hAP-Tunnel-226
SSID AREDN-10-v3
Channel -2
Bandwidth 10 Mhz
Signal/Noise/Ratio -57 / -95 / 38 dB
Charts
firmware version 692-bb818a9
configuration mesh
system time Mon Feb 18 2019 18:06:35 PST
uptime 1:09
load average 0.21, 0.15, 0.10
free space flash = 9184 KB /tmp = 30100 KB memory = 25648 KB
OLSR Entries Total = 1106 Nodes = 346
Part of the AREDN™ Project. For more details please see here

Mesh Status

AREDN
ANATEUR RADIO EMERGENCY DATA NETWORK

W6LY-RM2-Omni-LagunaWV mesh status

Location: 33.604102 -117.735125

Refresh | Auto | Quit

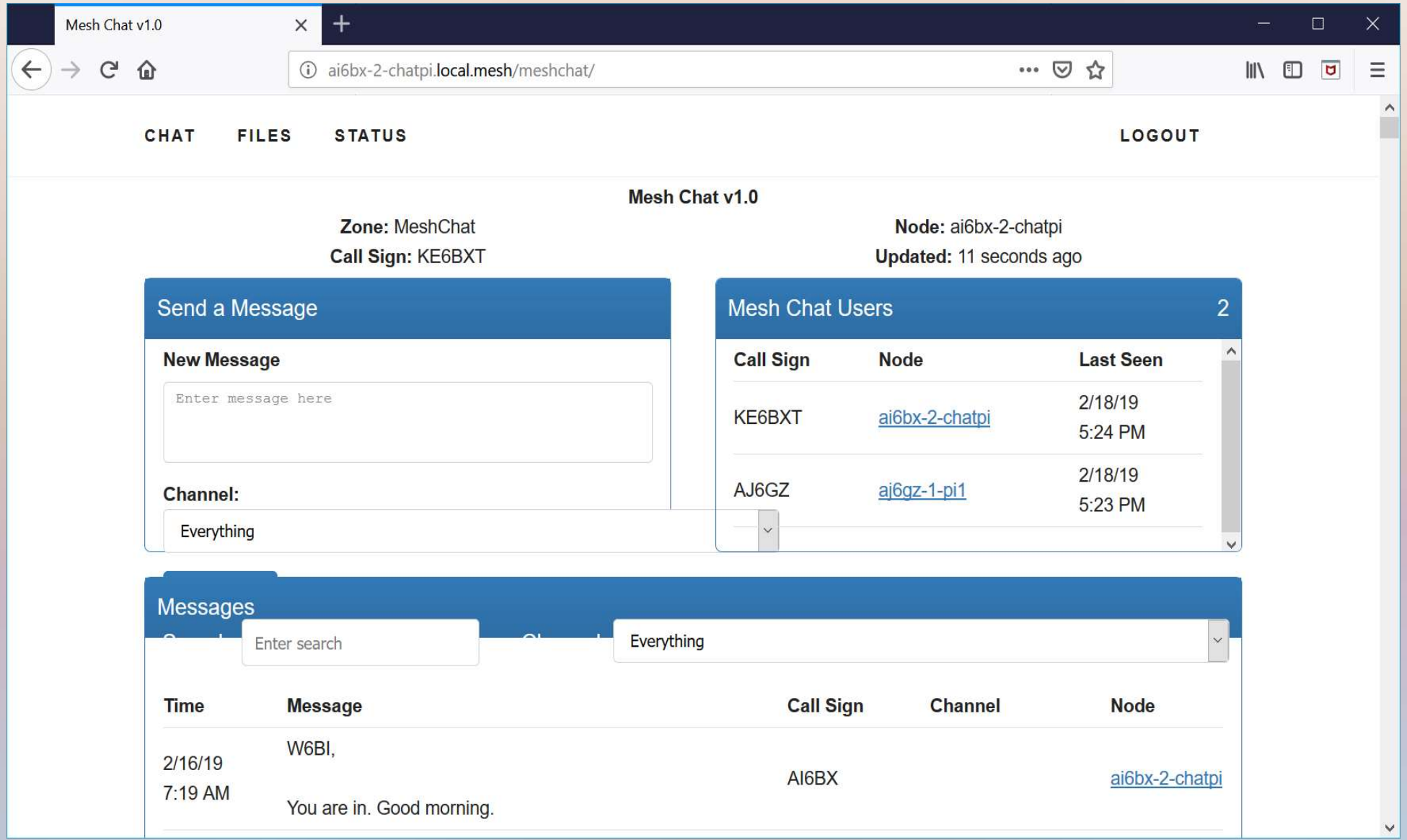
Local Hosts	Services
W6LY-RM2-Omni-LagunaWV.local.mesh	MeshChat
• gate14-HP.local.mesh	LW_DOC_SHARE

Remote Nodes	ETX	Services
	0.00	
• AI6BX-2-ToughSwitch.local.mesh		AI6BX-TS2
• ai6bx-raspbx.local.mesh		AI6BX-PBX
AE6XE-Saddleback-RM5.local.mesh	1.10	
• ae6xe-aircam1.local.mesh		rtsp-ipcam
• ae6xe-netgear1.local.mesh		netgearadmin
AE6XE-PleasantsPk-P2P-LagunaWoods.local.mesh	1.10	
WE6ER-NBM5-MV1.local.mesh	1.10	
• W6WTT-VOIP-QTH.local.mesh		10.197.41.211
AE6XE-PleasantsPk-P2P-Yucaipa.local.mesh	1.20	
AE6XE-PleasantsPk-RM2.local.mesh	1.20	
AE6XE-PleasantsPk-RM3.local.mesh	1.20	
• KE6BXT-PleasantsPk-TS8.local.mesh		admin
KE6BXT-PleasantsPk-RM5-SW.local.mesh	1.20	

Current Neighbors	LQ	NLQ	TxMbps	Services
AJ6B-M2NB-74-127-87.local.mesh	50%	84%	6.2	
KE6BXT-hAP-Tunnel-226.local.mesh (tun)	100%	100%		
• KE6BXT-226-Grandstream.local.mesh				Grandstream
• KE6BXT-226-Decode.local.mesh				Decoder
• KE6BXT-226-noname.local.mesh				No Name
• KE6BXT-226-raspberrypi.local.mesh				Raspi
• KE6BXT-226-H701.local.mesh				10.162.23.29
KI6IZE-RM2-KRUM.local.mesh	6%	61%	0.0	
• W6BGR-KrumCam.local.mesh				view view
W6LY-NSM2-LWV-CTOWER.local.mesh	63%	85%	12.4	
• W6LY-Shack-FAX.local.mesh				10.117.187.164 FAX
• W6LY-CTOWER-CAMERA.local.mesh				Take Snapshot
• W6LY-GPX2160.local.mesh				10.117.187.162x1060
W6LY-RM5-RDish-LWV-PP.local.mesh (dtd)	100%	100%		
• W6LY-Gate14-SCE9BA7C.local.mesh				Take snapshot
W6LY-RM5-RDish-LWV-SB.local.mesh (dtd)	100%	100%		

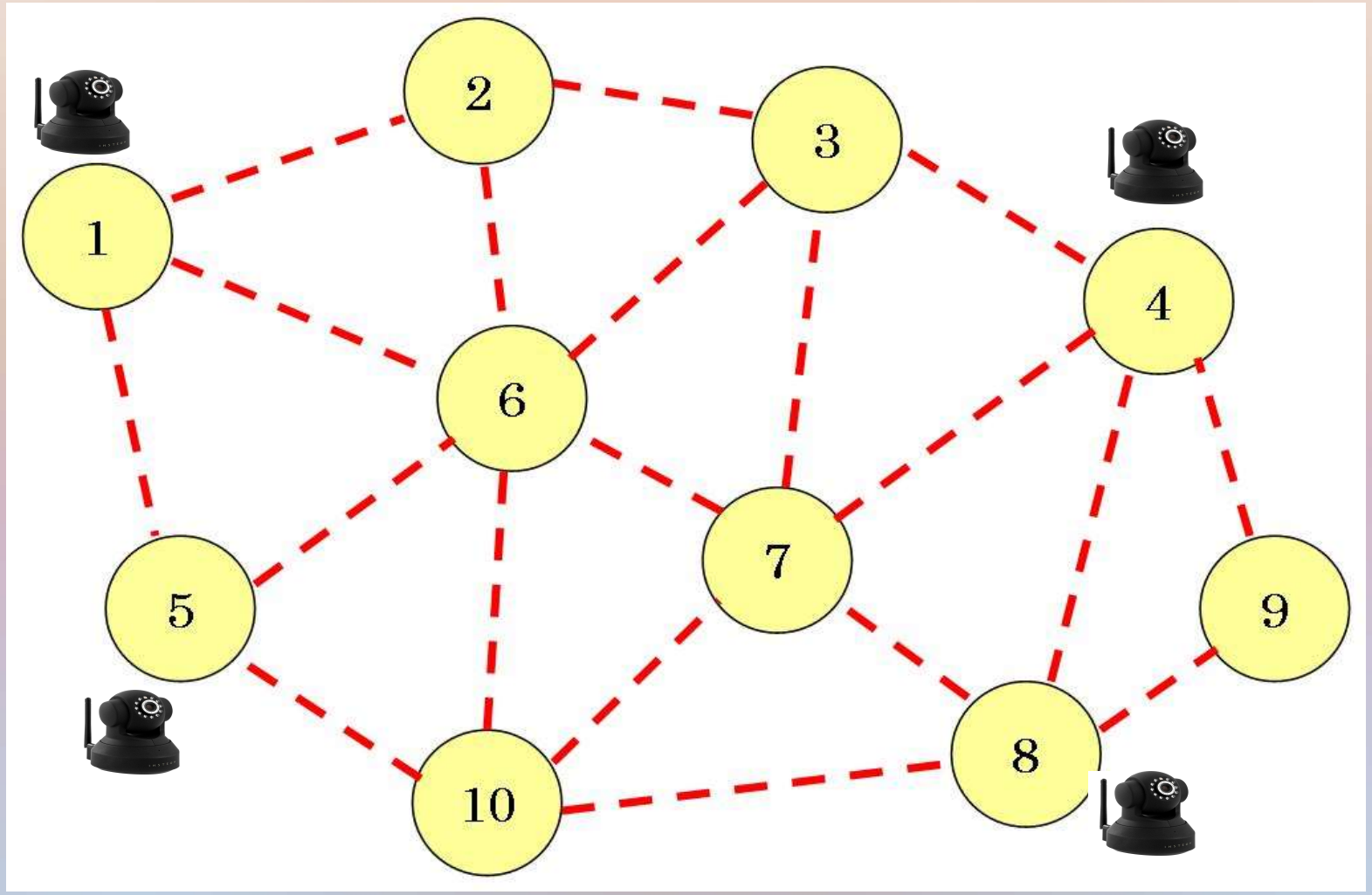
Previous Neighbors	When

MeshChat


Mesh Chat v1.0
ai6bx-2-chatpi.local.mesh/meshchat/
CHAT
FILES
STATUS
LOGOUT
Mesh Chat v1.0
Zone: MeshChat
Call Sign: KE6BXT
Node: ai6bx-2-chatpi
Updated: 11 seconds ago
Send a Message
New Message
Enter message here
Channel:
Everything
Mesh Chat Users
2
Call Sign
Node
Last Seen
KE6BXT
ai6bx-2-chatpi
2/18/19
5:24 PM
AJ6GZ
aj6gz-1-pi1
2/18/19
5:23 PM
Messages
Enter search
Everything
Time
Message
Call Sign
Channel
Node
2/16/19
7:19 AM
W6BI,
You are in. Good morning.
AI6BX
ai6bx-2-chatpi

You'll want an IP Camera

… or several IP Cameras



Do you want to talk over the network? Add phones using a VoIP adapter

With a VoIP Video Phone you can talk and see

Add a Raspberry Pi

or Arduino or BeagleBoard

- Web server
- File server
- Asterick server (PBX)

Access, monitor and control USB devices over your network

Access your HAM radio remotely (HAM radio over HAM radio)

RemoteRig
1258MKIIS-RADIO
STEREO (DUAL RX) RADIO SIDE UNIT REMOTERIG

HRO Discount Price: **$285.95**

This item qualifies for **FREE SHIPPING**
In 48 Continental US States by UPS Ground Service

Add To Cart

RS232 to TCPIP/RJ45 Converter
Serial to Ethernet Server

You can turn power on or off

[Front Panel]

[5]: RS-232 Serial Port Console
[6]: Outlet LED Indication
[7]: Circuit Breaker
[8]: Master Power On/Off Button
[1]: Ethernet Port
[2]: Manual On/Off Button
[3]: Manual Power Outlet Selection Button
[4]: Loop Through For Daisy-Chain Connection

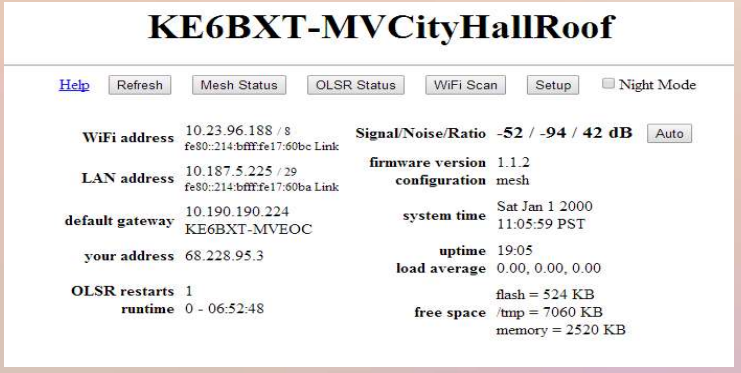
[Back Panel]

~~Control~~ Monitor the weather

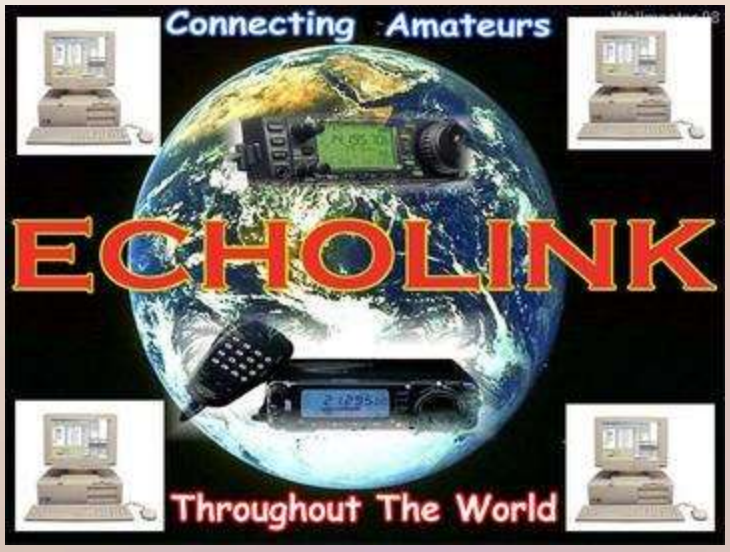
What would you add to your MESH network?

Connecting your MESH network to the Internet

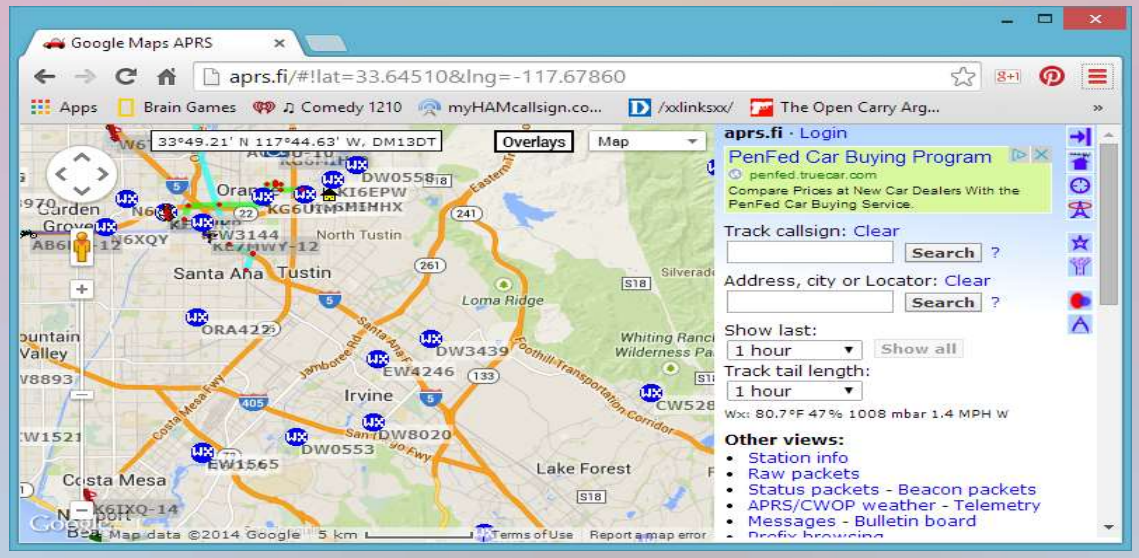
Monitor/control nodes and service from anywhere with internet access



Access HAM Internet services



WebEOC



Orange County Mesh Organization

Search this site

Home | More Nodes in Orange County | Bands, Channels, and Frequencies | Band Plans | OC RACES | Backbone Nodes | Events | Hardware | Software (Firmware) | Basic Setup | Services | External Links | FAQs | Contact Us

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  - Pleasants Peak
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  - San Juan Capistrano
- Bands, Channels, and Frequencies
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- More Maps
  - More Nodes in Orange County
  - AREDN Node Map
  - OC RACES
  - S.A.T.E.R.N.
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  - AirGateway
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- Software (Firmware)
- Basic Setup
- Internet Tunneling
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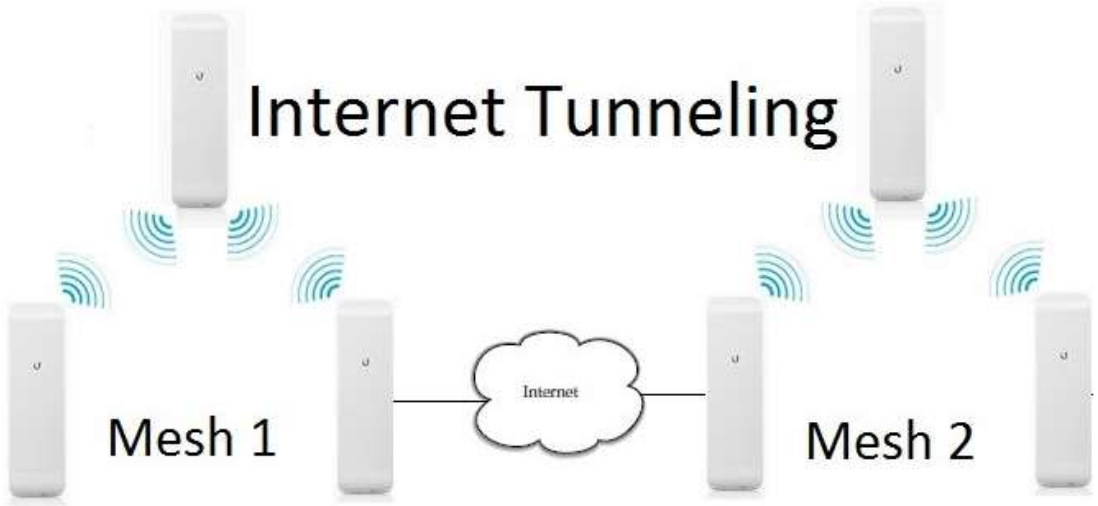
Internet Tunneling

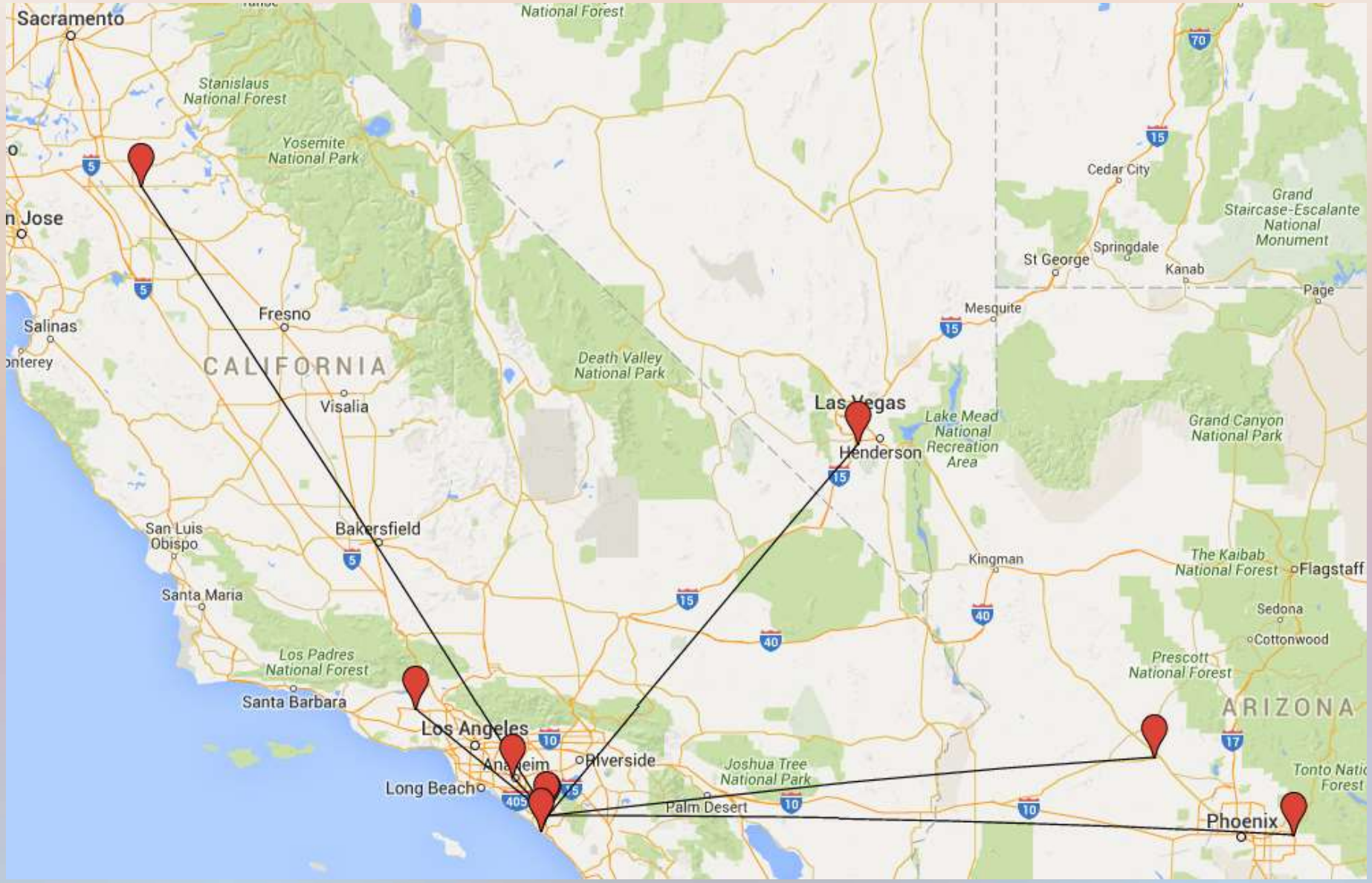


Internet Tunneling is a method to connect Mesh Islands together using the Internet. Each AREDN Mesh Node has the capability to ether be a Tunnel Server, a Tunnel Client, or both a Tunnel Server and a Tunnel Server.

After flashing the AREDN firmware on your node you must install the Tunneling software before you can configure it. Click on the Setup button to go to the Basic Setup page. Next, click on ether the Tunnel Server or Tunnel Client links. If the Tunnel software has not yet been installed you will see one of the following messages:

Connecting Mesh Islands

Internet Tunneling



Links

- Orange County Mesh Organization

  http://OCMESH.org

- AREDN website (Amateur Radio Emergency Data Netwohrk)

  http://AREDNMESH.org

- Orange County “real-time” Map

  https://mapping.kg6wxc.net/meshmap/map_display.php

- Speed Test

  http://www.speedtest.net/

And finally....

Ready for some Demos?

THE END

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joe@ayerscasa.com