



Mesh Networking
Mathison Ott KJ6DZB
[QSL.net/kj6dzb/ham](https://qsl.net/kj6dzb/ham)

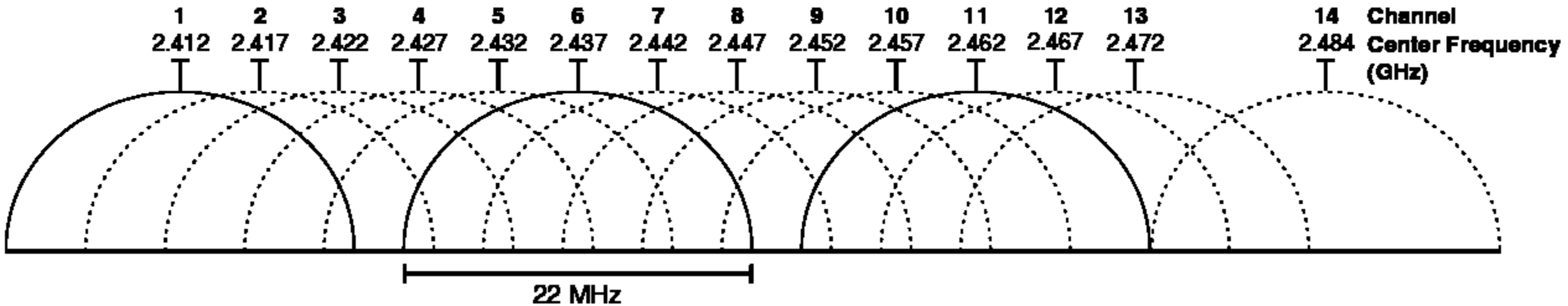
Spectrum Allocations

Multiple band plans EXIST !

- **13 Centimeters Band 2.4gh**
- ARRL (2300-2310 and 2390-2450 MHz)
- **10cm Centimeters Band 3ghz**
- ARRL (3300-3500 MHz)
- **5cm Centimeters Band 5ghz**
- ARRL (5650.0-5925.0 MHz)

<http://www.arrl.org/band-plan>

List of ISM WLAN channels



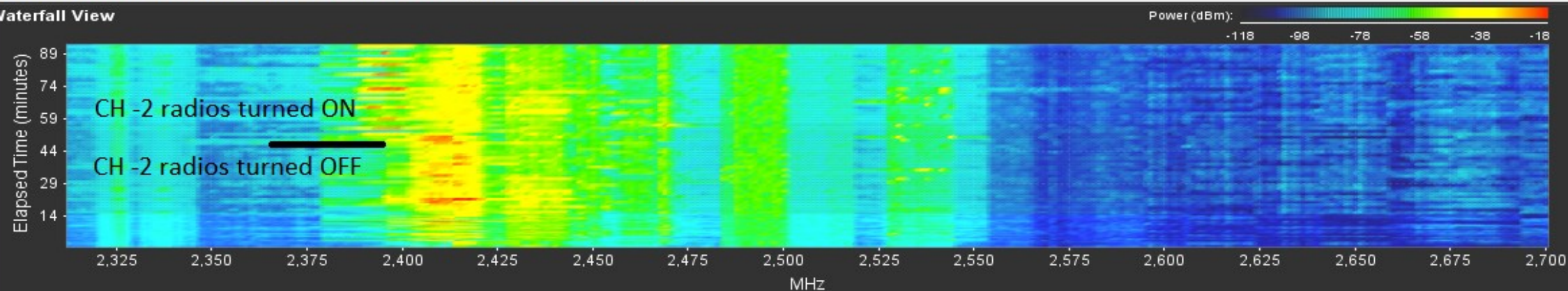
AirView Spectrum Analyzer

File View Help

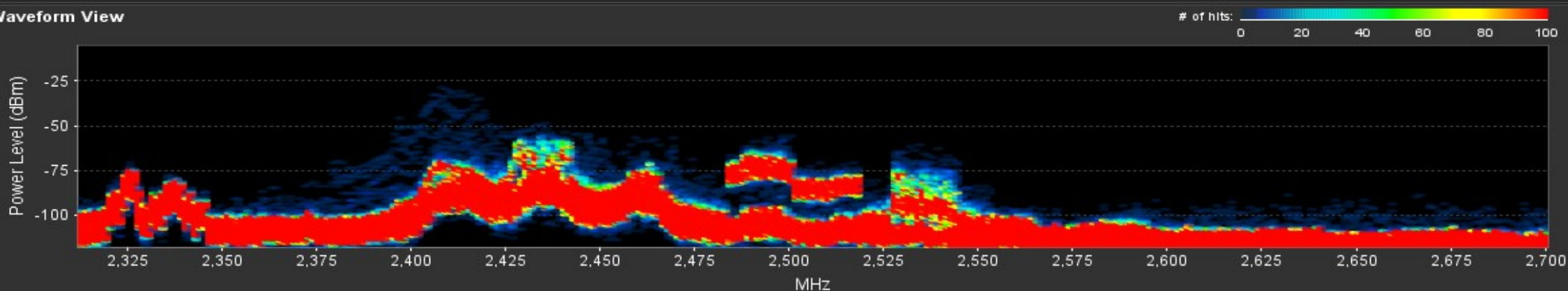
Device: NanoStation M2 (687251088137) on ubnt://192.168.3.23:18888 | Total RF Frames: 11699 | FPS: 2.3

Reset All Data

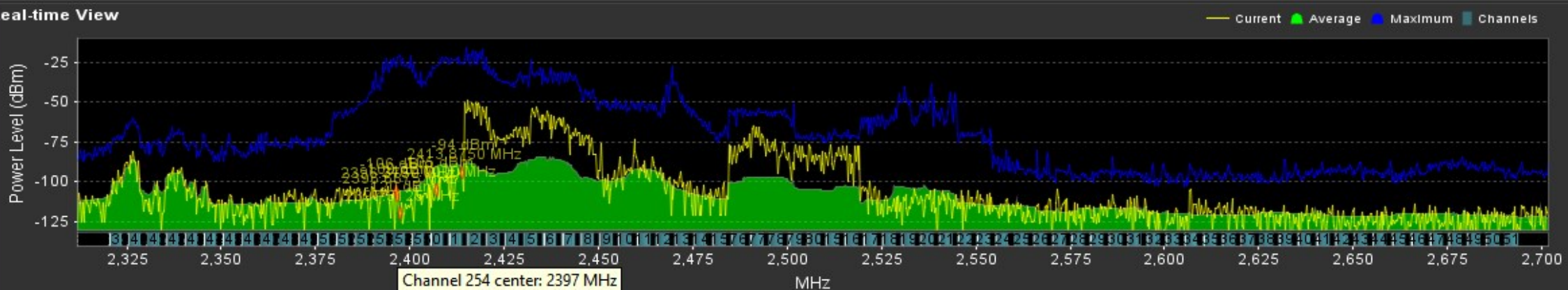
Waterfall View



Waveform View



Real-time View



2.4ghz

NOTE

Broadband Modes, 2410.000-2450.000, 22 MHz max.

Broadband segment may be used for any combination of high-speed data (e.g. 802.11 protocols), Amateur Television and other high-bandwidth activities. Division into channels and/or separation of uses within this segment may be done regionally based on needs and usage.

2424.100 is the Japanese EME transmit frequency

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

24 Non-Shared Channels on 3.4 GHz

3.4 GHz	Channel	76	77	78	79	80	81	82	83	84	85	86	87
	Status	Ham Band											
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
Channel	88	89	90	91	92	93	94	95	96	97	98	99	
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

Refer to your local band plan for coordination

5ghz(5650.0-5925.0 MHz)

Broadband segment may be used for any combination of high-speed data (eg: 802.11 protocols), Amateur Television and other high-bandwidth activities. Division into channels and/or separation of uses within this segment may be done regionally based on needs and usage.

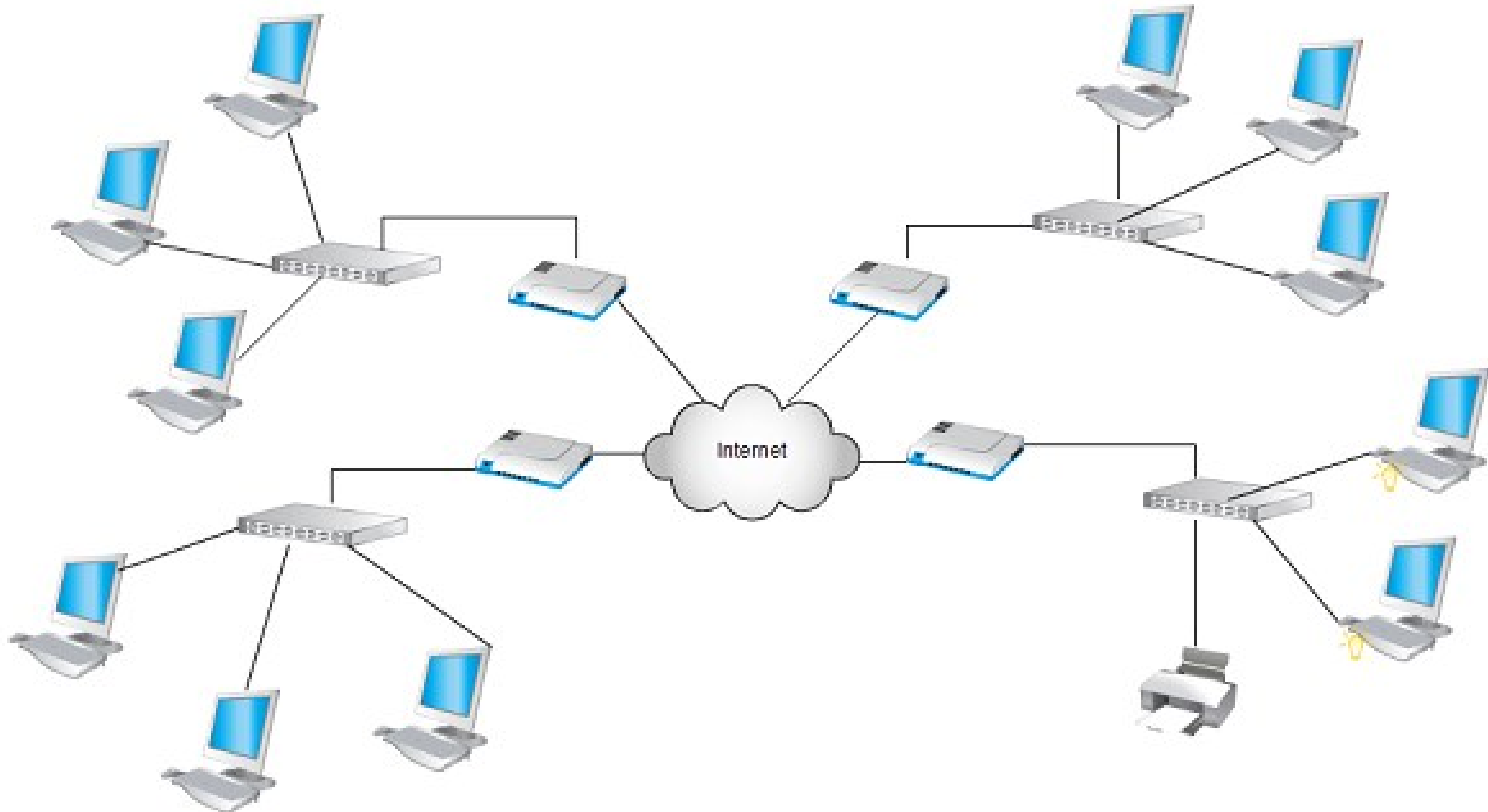
52 Channels, 7 Non-Shared, on 5.8 GHz

5.8 GHz	Channel	133	134	135	136	137	138	139	140	141	142	143	144	145
	Status	Shared Ham and ISM/WiFi Band												
	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
		Shared Ham and ISM/WiFi Band												
		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
		Shared Ham and ISM/WiFi Band												
		5.795	5.800	5.805	5.810	5.815	5.820	5.825	5.830	5.835	5.840	5.845	5.850	5.855
		172	173	174	175	176	177	178	179	180	181	182	183	184
		Ham Band												
		5.860	5.865	5.870	5.875	5.880	5.885	5.890	5.895	5.900	5.905	5.910	5.915	5.920

Refer to your local band plan for coordination

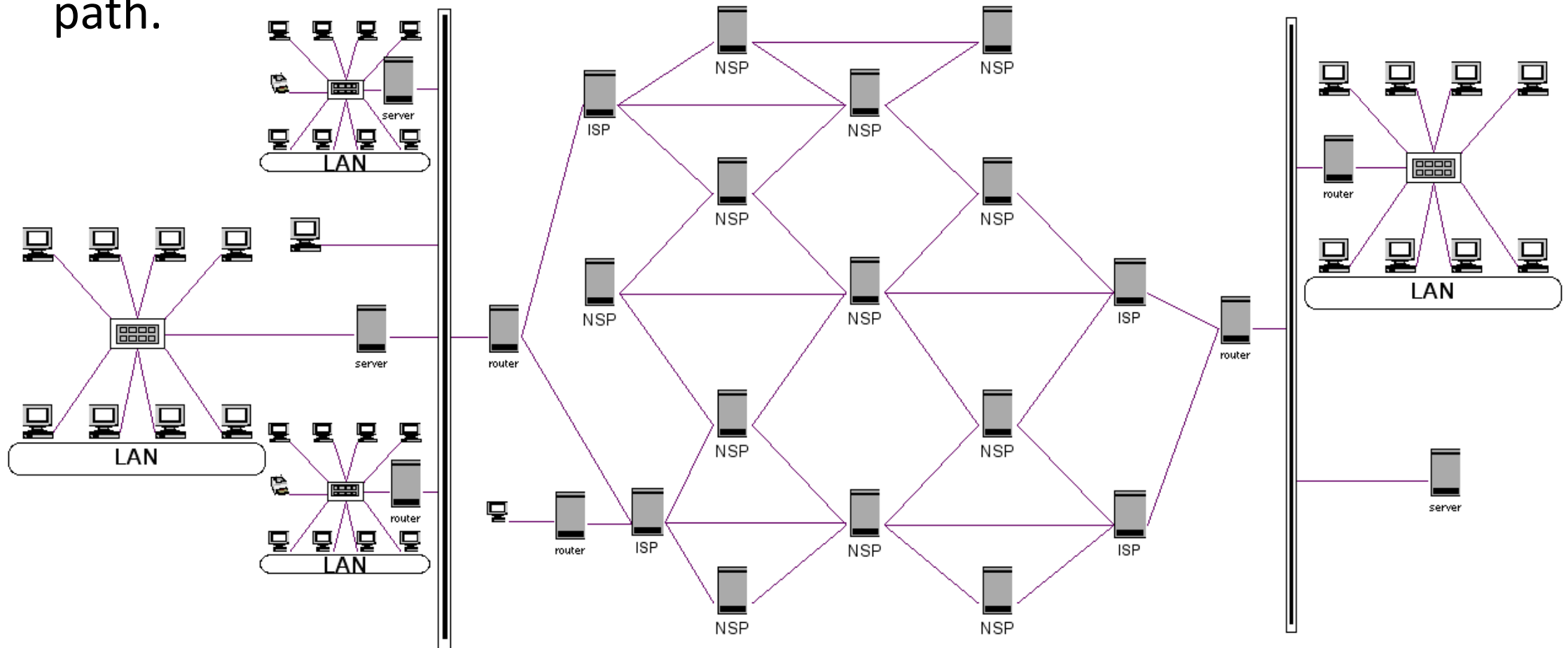
WHAT'S a MESH!
Again?

Types of network Topography



The Internet (INTERconnected NETworks)

- The internet is fault tolerant! If one path goes down there is another path.



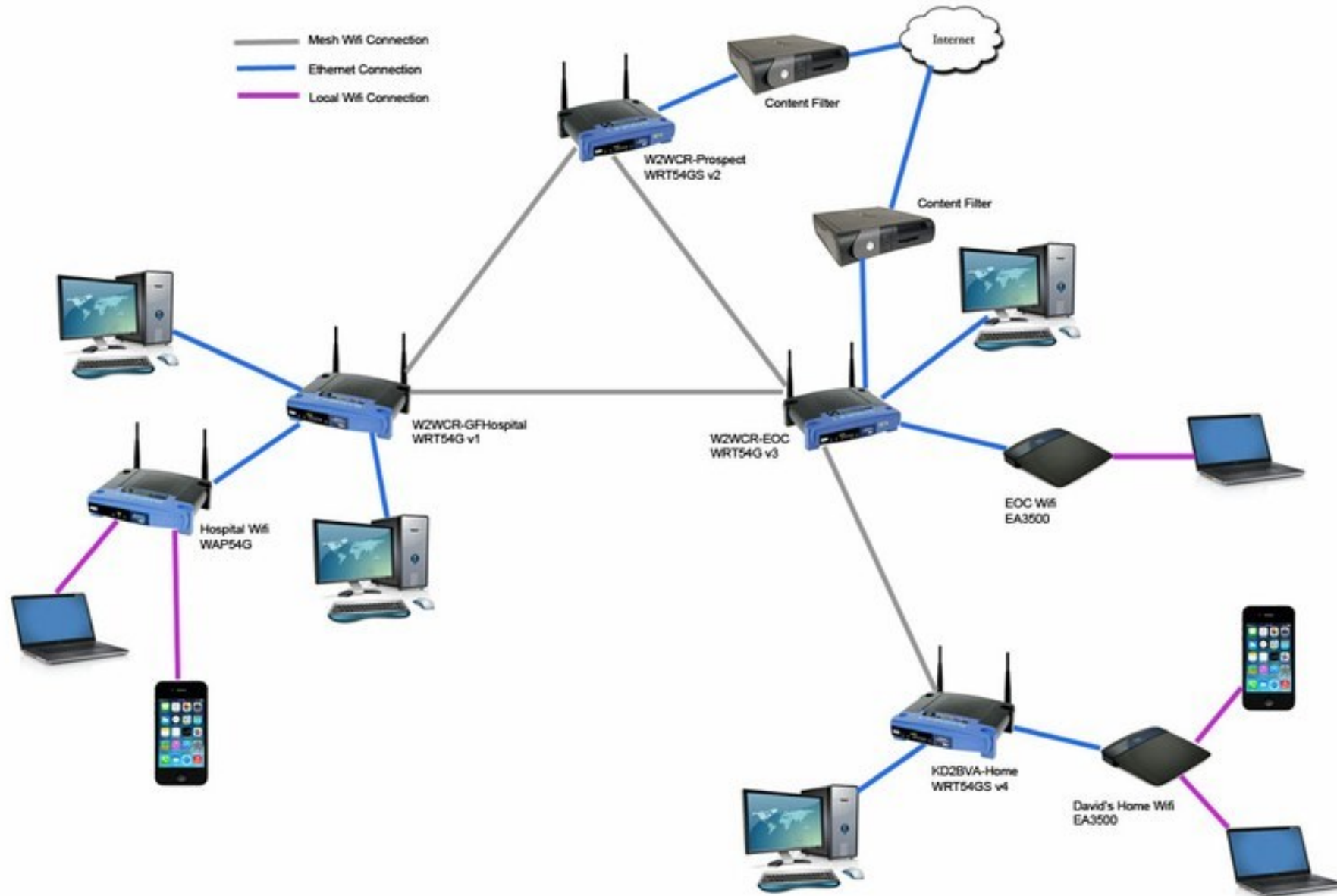
olsrd

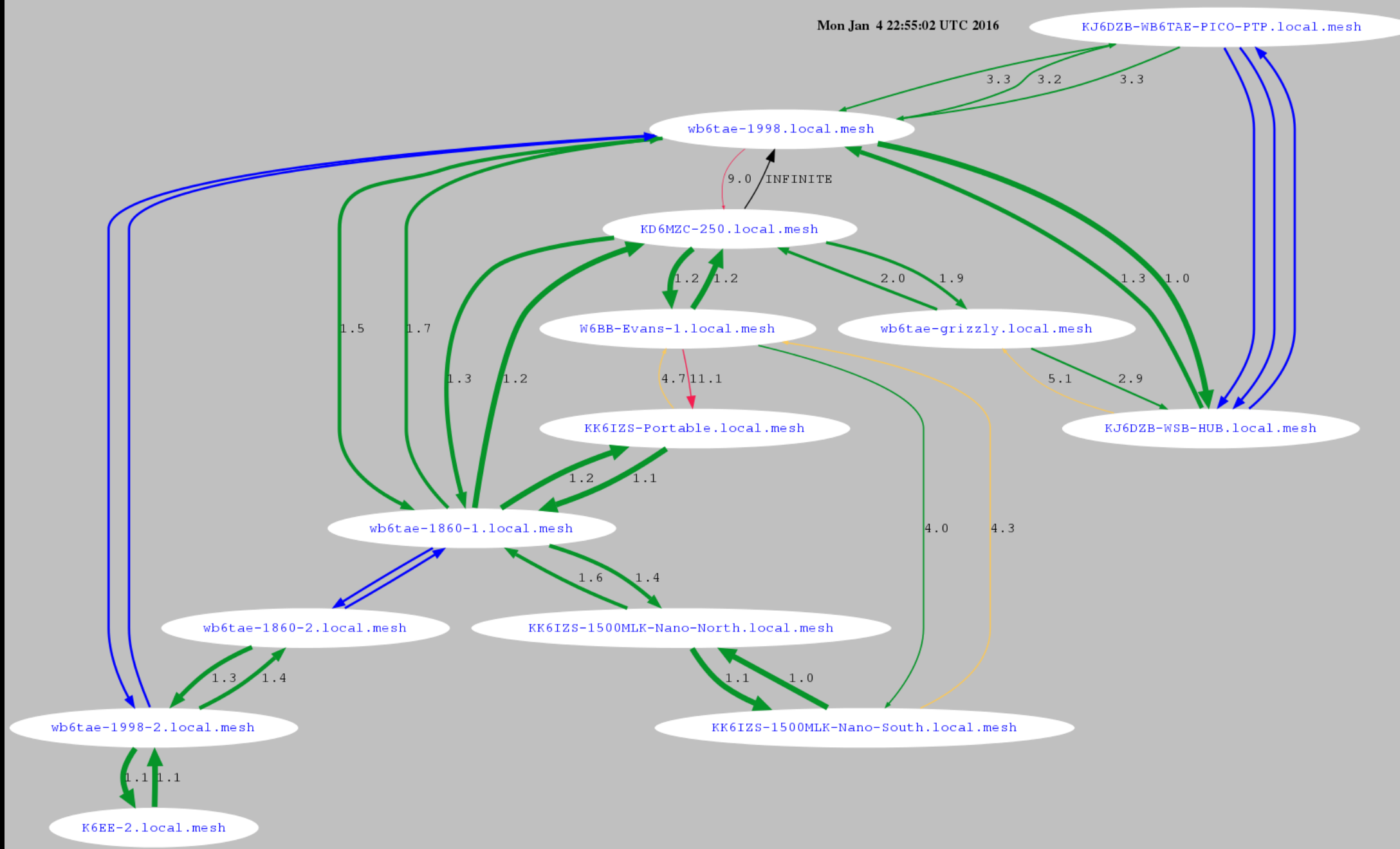
an adhoc wireless mesh routing daemon

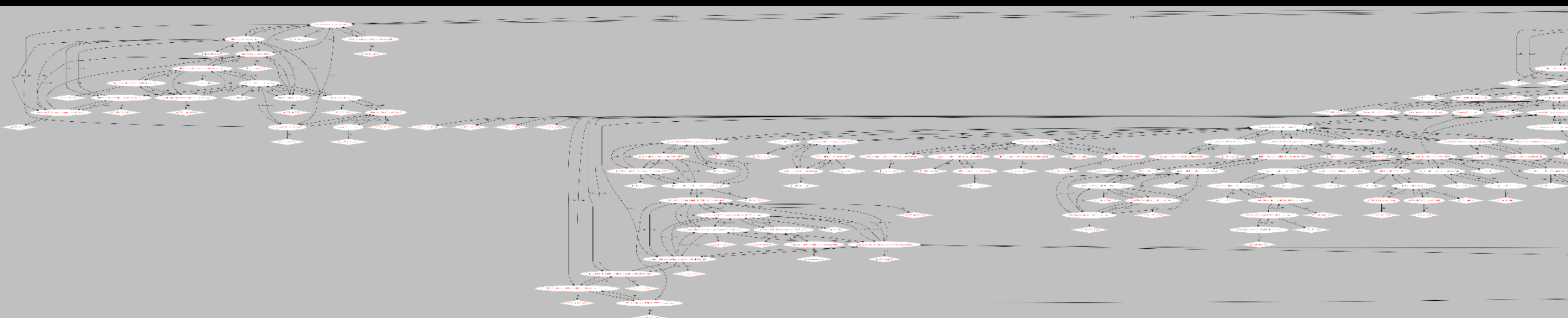
What is OLSR ?

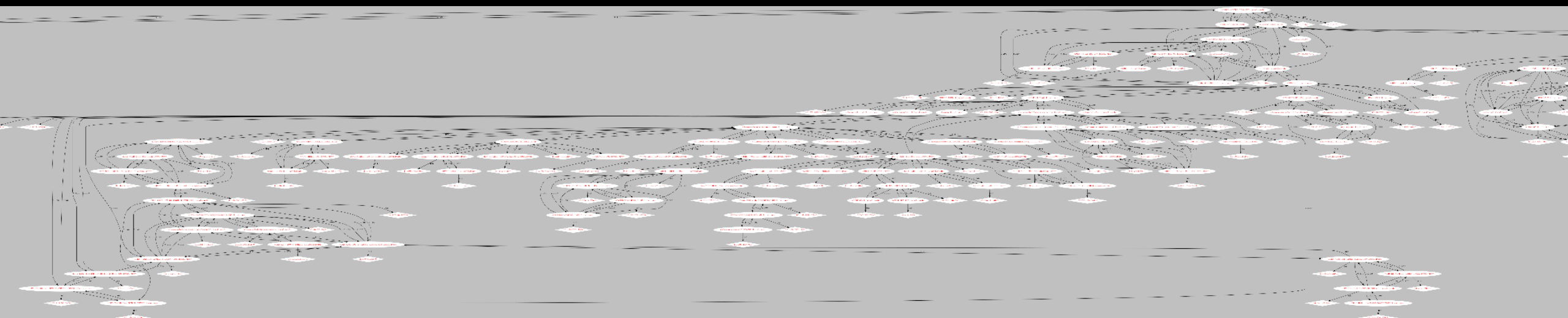
The **Optimized Link State Routing protocol** (**OLSR**) is a routing protocol that is optimised for mobile ad-hoc networks but can also be used on other wireless ad-hoc networks. It is a proactive link-state routing protocol that floods a topology table of it's neighbors to all nodes in the network which then compute optimal forwarding paths locally.

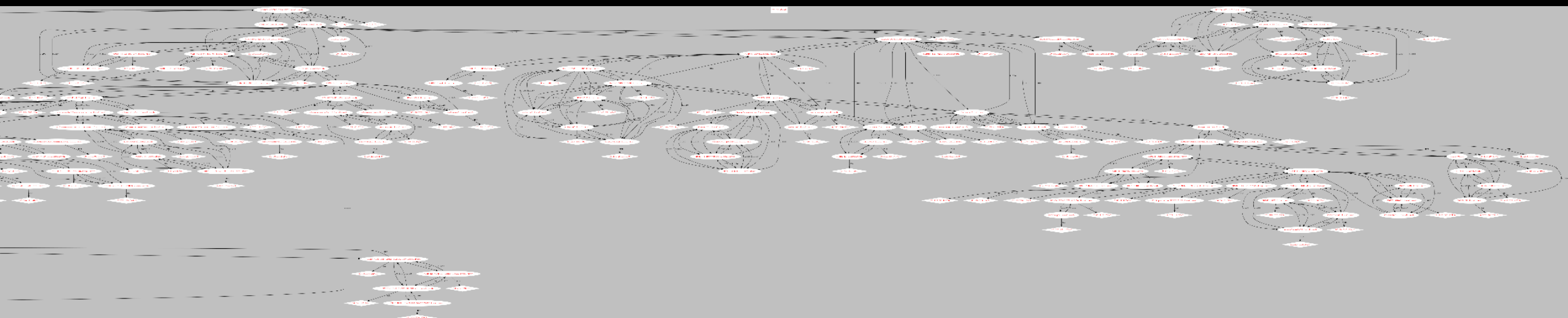
Mesh Topography











What Software is used to build a mesh



Broadband-Hamnet
formerly
HSMM-Mesh



A RED N

AMATEUR RADIO EMERGENCY DATA NETWORK



HSMM-Pi project

Script based install for a RPI aka Debian, Ubuntu. Installs on a fresh OS image!

-Standard stuff to get a RPI going!

-You will need a Wifi Dongle, external antenna? Your going to be Stuck with the ISM band (for now)
Alto some cards have coverage into -1,-2 ch, the kernel firmware isn't compiled by default to do so.

-Low power General purpose server that runs off 5v!! (Its NO i7!) More RAM than a node! IO pins!

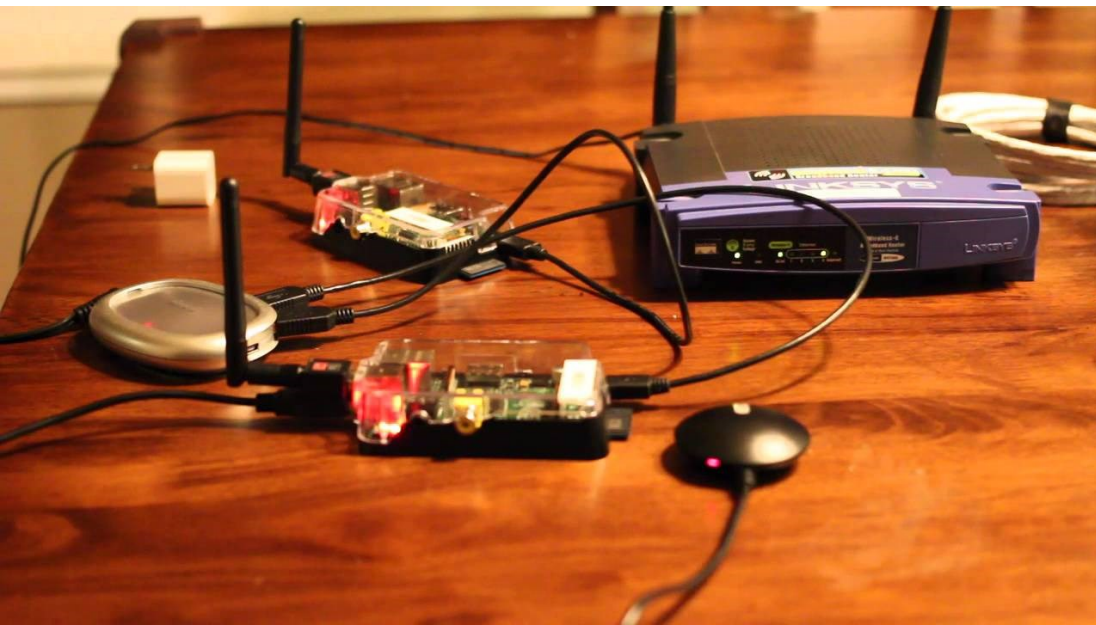
-APRS! With usb GPS and PITNC.

-VOIP server, Web server! Run scripts!

I have 5 for various tasks!

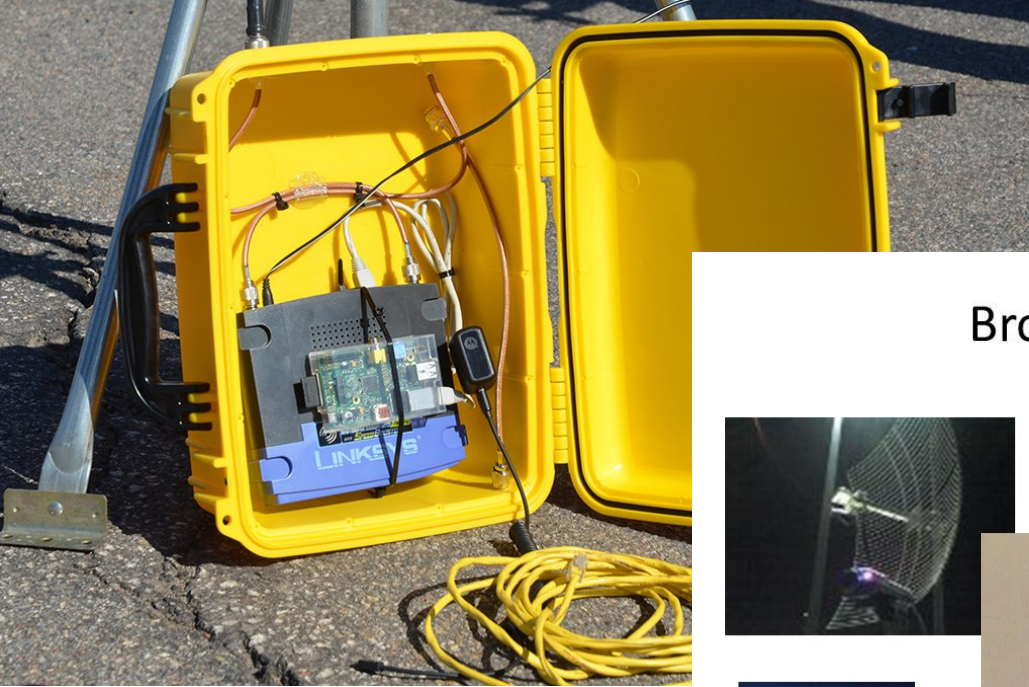
Fun and vestal

in the end they cost more than the Ubiquiti gear.



WRT54G

15year old 802.11 B,G



Broadband-Hamnet
formerly
HSMM-Mesh



only 2.4ghz

- Low starting price
- limited memory
- Low power ~12dbi.
- External diversity antennas.
- After market external antennas needed!
- Not weather sealed.
- run on 12v.



RP TNC to N pigtail

2 WRT-54G routers, one "B" AP router

Crappy homebrew antenna.



Amateur Radio Emergency Data Network

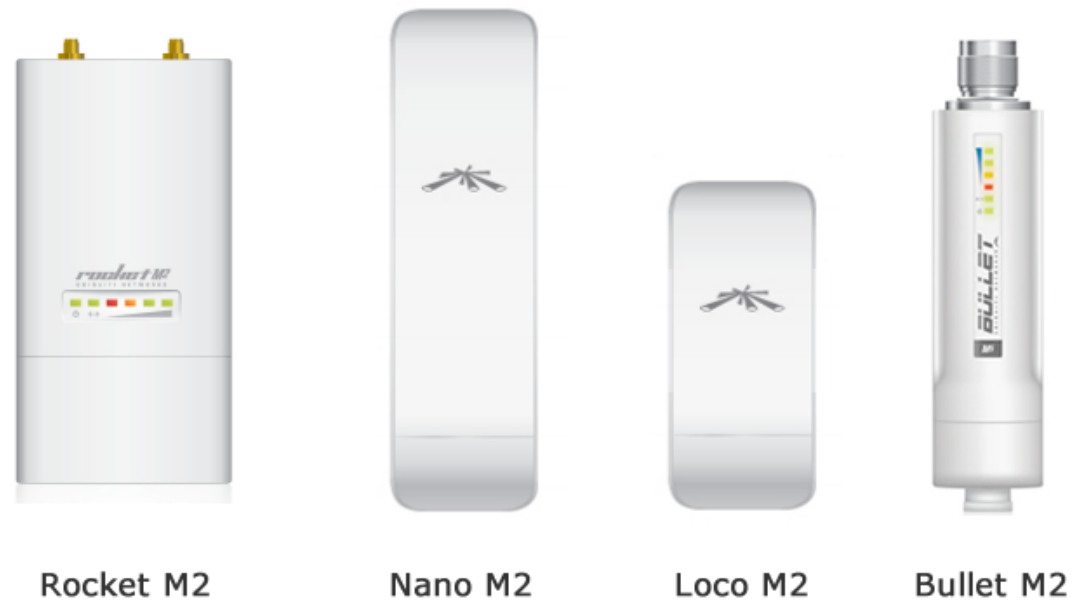
- Amateur Radio Emergency Data Network

12/24v POE!

Weather prof!

900mhz!
2.4ghz!
3ghz!
5ghz!
802.11 B G N

AirMax M2 series



Supported Platform Matrix

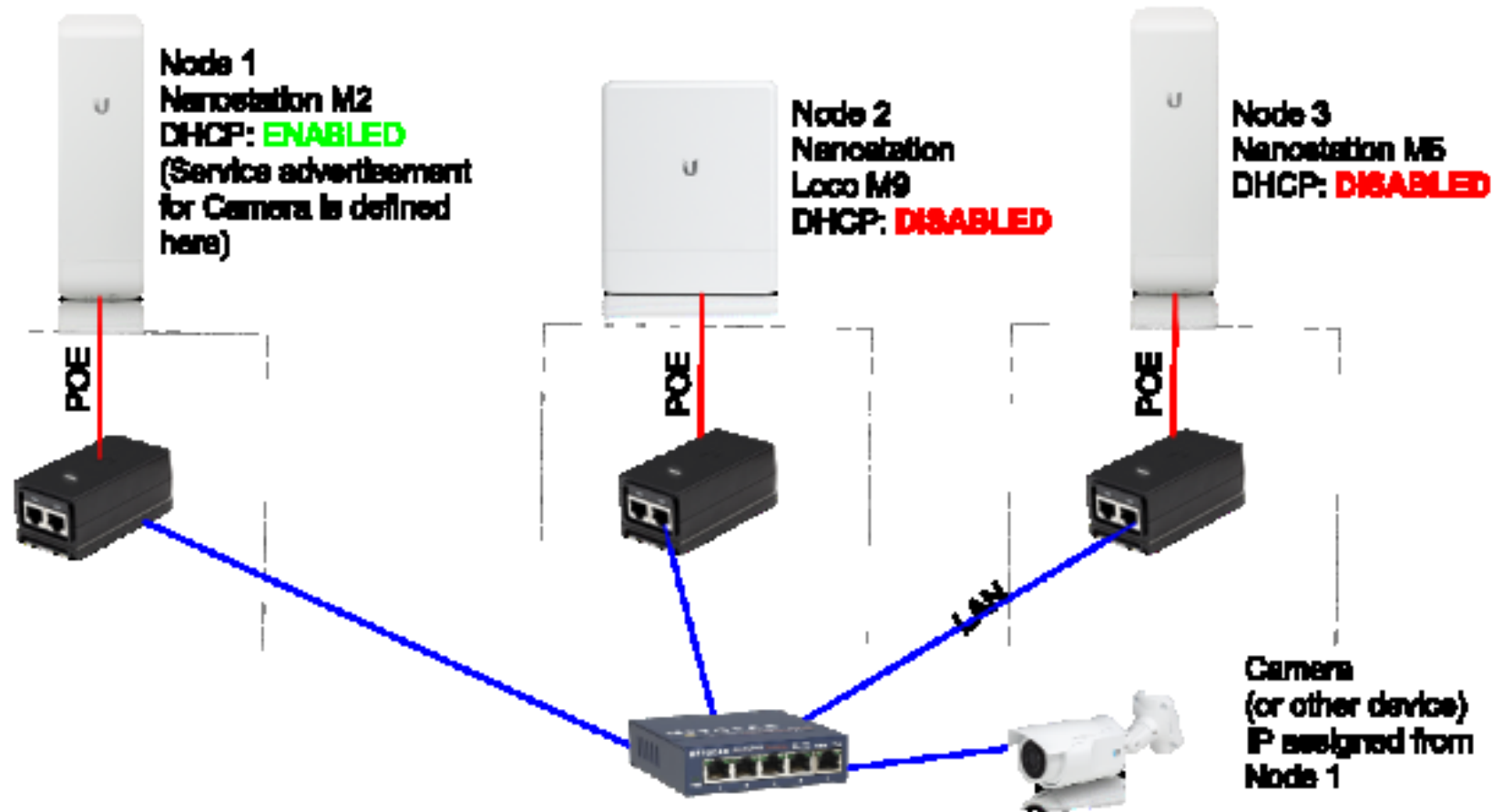
The supported platform matrix identifies the make and models of hardware which may be used with AREDN firmware in the various frequency bands. The equipment marked with a green background is fully supported and tested. Models with a red background are NOT supported nor are they compatible with AREDN firmware. The orange background indicates equipment that is likely to work well, but has not yet been thoroughly tested. Equipment with a yellow background is in the research stage and may or may not achieve fully-supported status depending on test results.

Current As of AREDN™ 3.16.1.0 (updated on 09/27/2016)				
Manufacturer/Model	Band			
	900Mhz	2.4Ghz	3Ghz	5.8Ghz
Ubiquiti Networks (www.ubnt.com)				
AirGrid (XM revision/old)		M2		M5
AirGrid (XW)				AG-HP-5Gxx
AirRouter		M2		
AirRouter HP		M2		
Bullet		M2		M5
Bullet Titanium		M2		M5
NanoBeam (XW)				NBE-M5-16/19
NanoBridge	M3	2G18	M3	5G27/3G25
NanoStation Loco (XM)	M3	M2		M5
NanoStation Loco (XW)				M5
NanoStation (XM)		M2	M3	M5
NanoStation (XW)				M5
PicoStation		M2		
PowerBeam (see note 3)		PBE-M2-400		PBE-M5-300/400
PowerBeam				PBE-M5-620
Rocket (XM)	M3D	M2	M3	M5
Rocket (XW)				M5
Rocket Titanium		M2		M5
Rocket Titanium (XW)				M5
TP-Link				
CPE		CPE310		CPE510
-				
GREEN = "GO"	AREDN Supported			
RED="STOP"	No Compatibility or Support			
ORANGE="CAUTION"	High Confidence of compatibility. Included in current release, but not rigorously tested			
YELLOW="RESEARCHING"	Under research for future support consideration.			
GREY="N/A"	No such device			
**	In beta			



Device-To-Device (DtD) Linking

Three+ Node Site w/Non-802.1q VLAN Switch



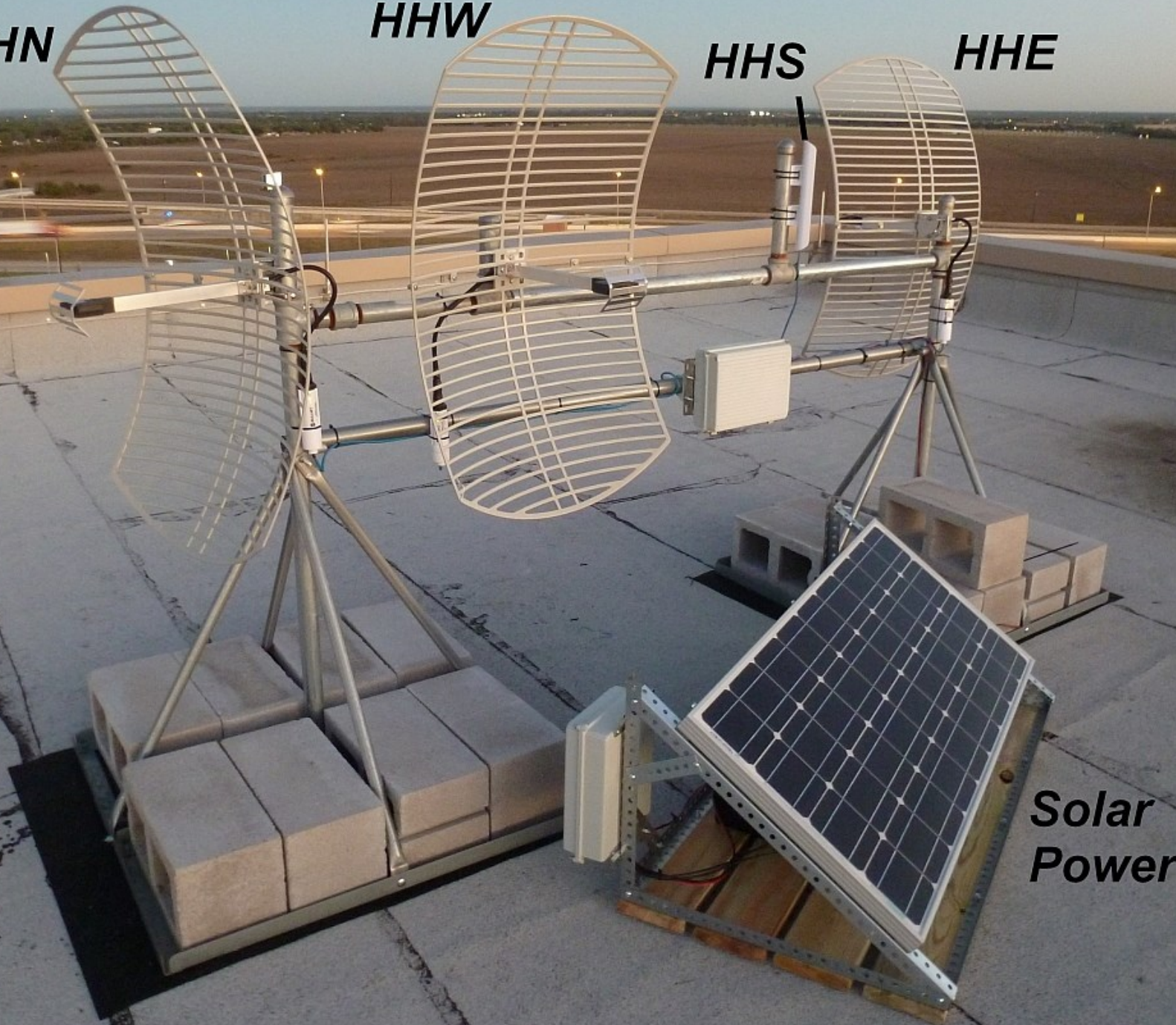
***CAUTION:** Do not disable DHCP on ALL nodes!

HHN

HHW

HHS

HHE



Power

- Use the supplied 240/120 → 24v .
- Solar w/ battery for a 12 or 24v system
 - Managed charging or unmanaged?
 - Fixed solar panel

~25w 1node

~50w 2node

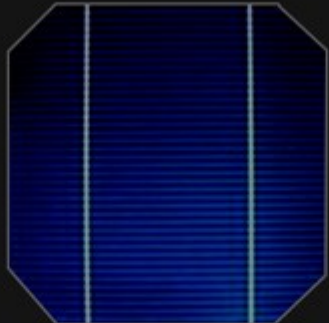
You need to figure out you power consumption margin for Winter and Summer at a site.

- Weather proofing →

Buy Local panels like Sun Power, or Solar City!



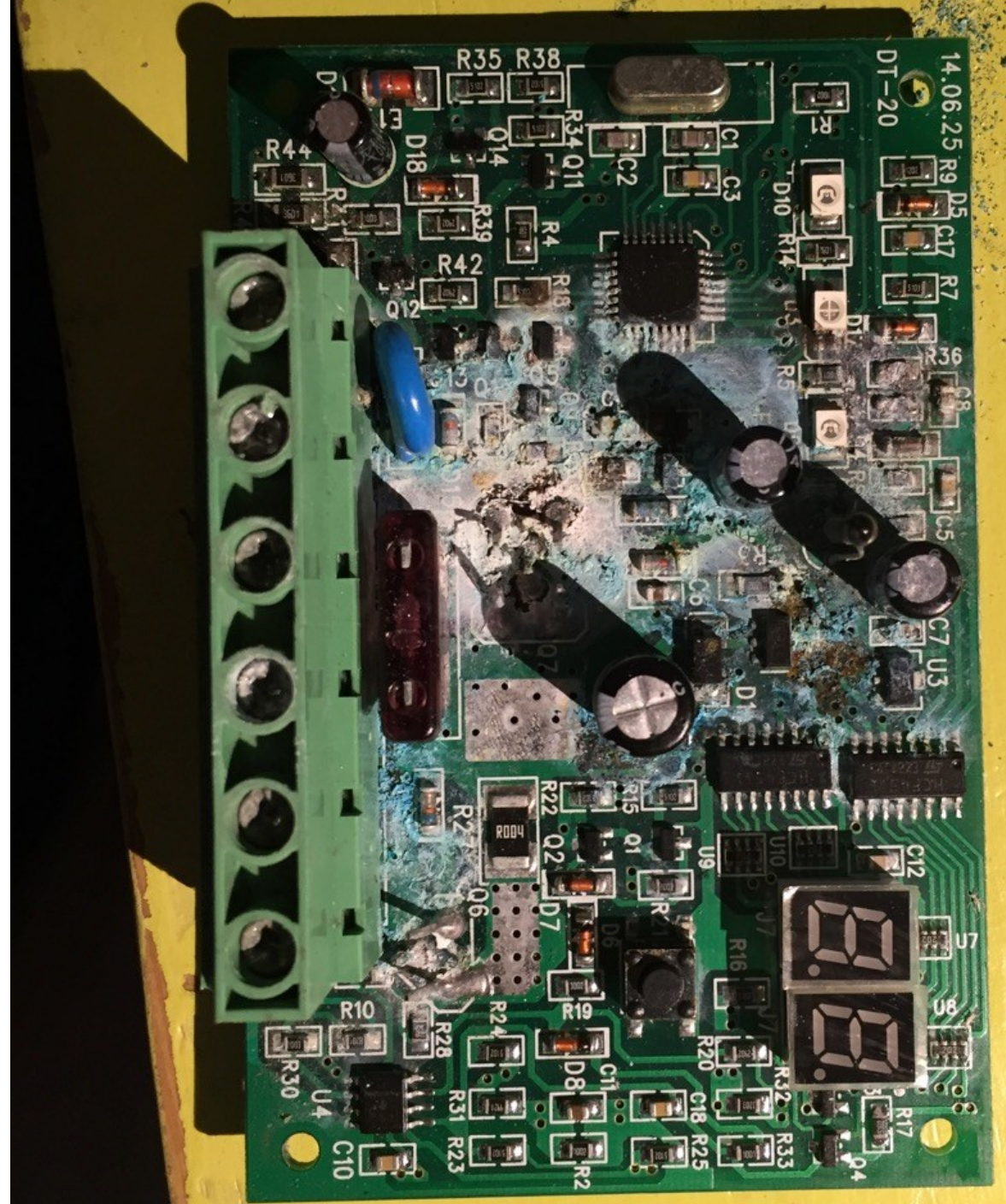
Conventional cells
Polycrystalline 14-16% efficiency



Conventional cells
Monocrystalline 15-17% efficiency



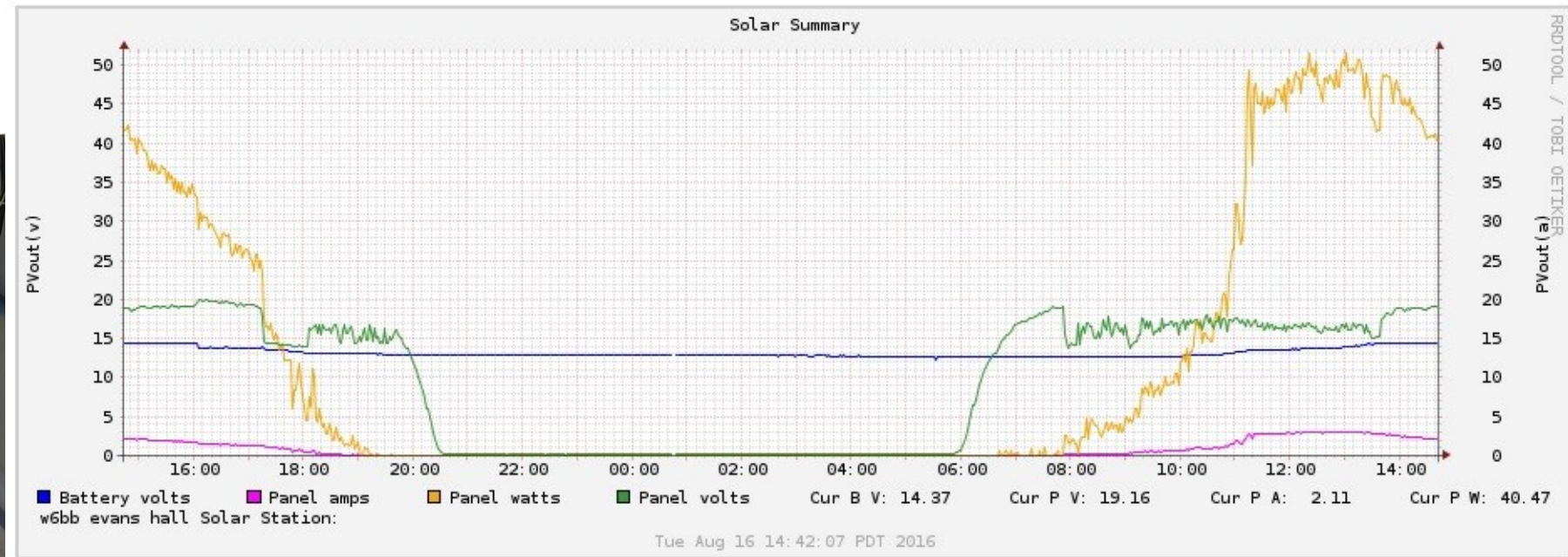
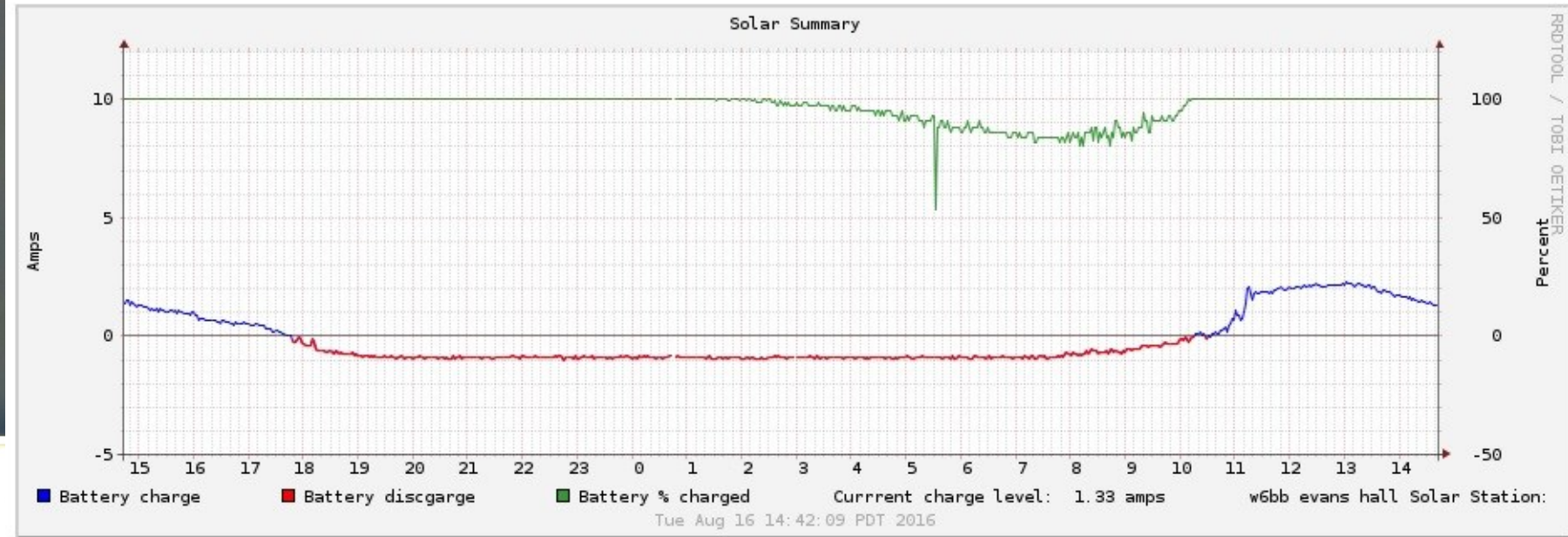
MAXEON™ CELL
24.2% efficiency





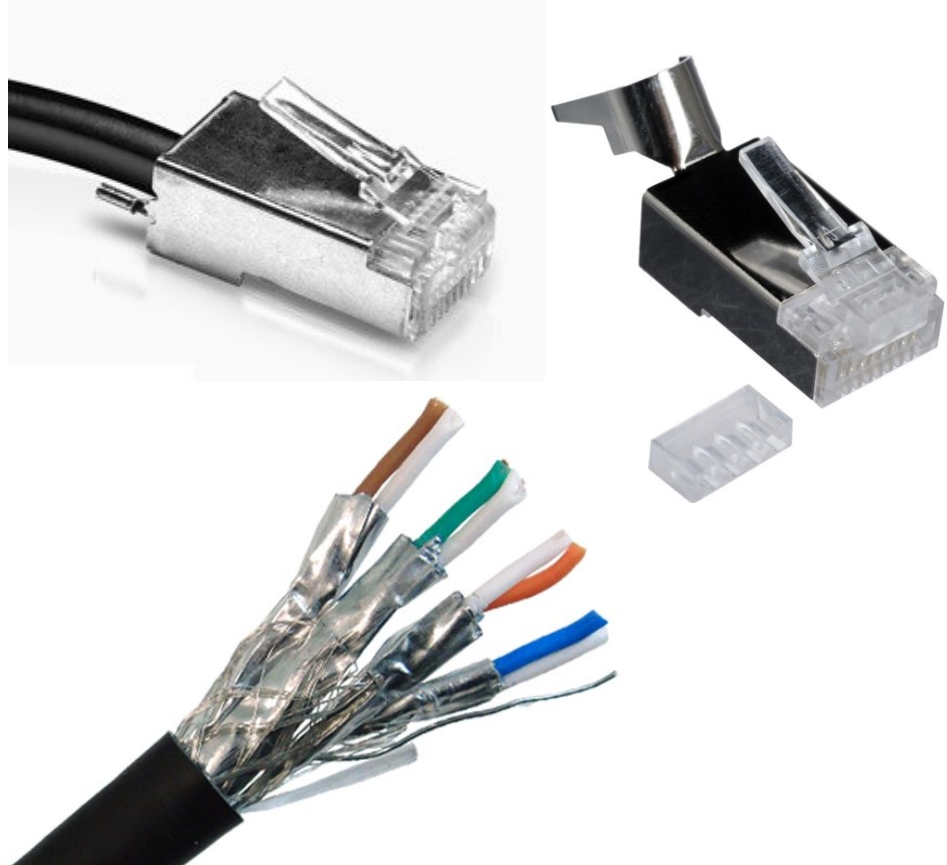
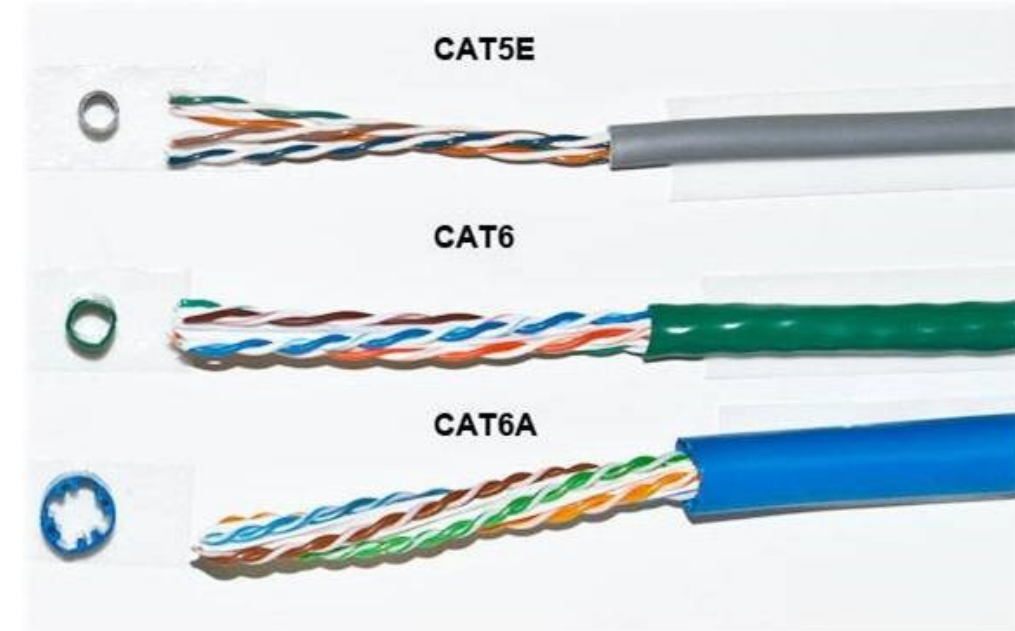
Solar Power Activity for the Past 24 Hours

This page will automatically refresh every minute



Cable

- Cat6 utp (unshielded twisted pair w/ crosstalk protection)
- Cat5e / Cat6a is [ANSI/TIA-568-C.1](#) (crosstalk protection, unshielded)
- Cate 7a (crosstalk and EMI protection w/ Overall Cable Shield)
- Shielded connectors
- Nodes shielded (Titanium models)
- Near field antenna separation.

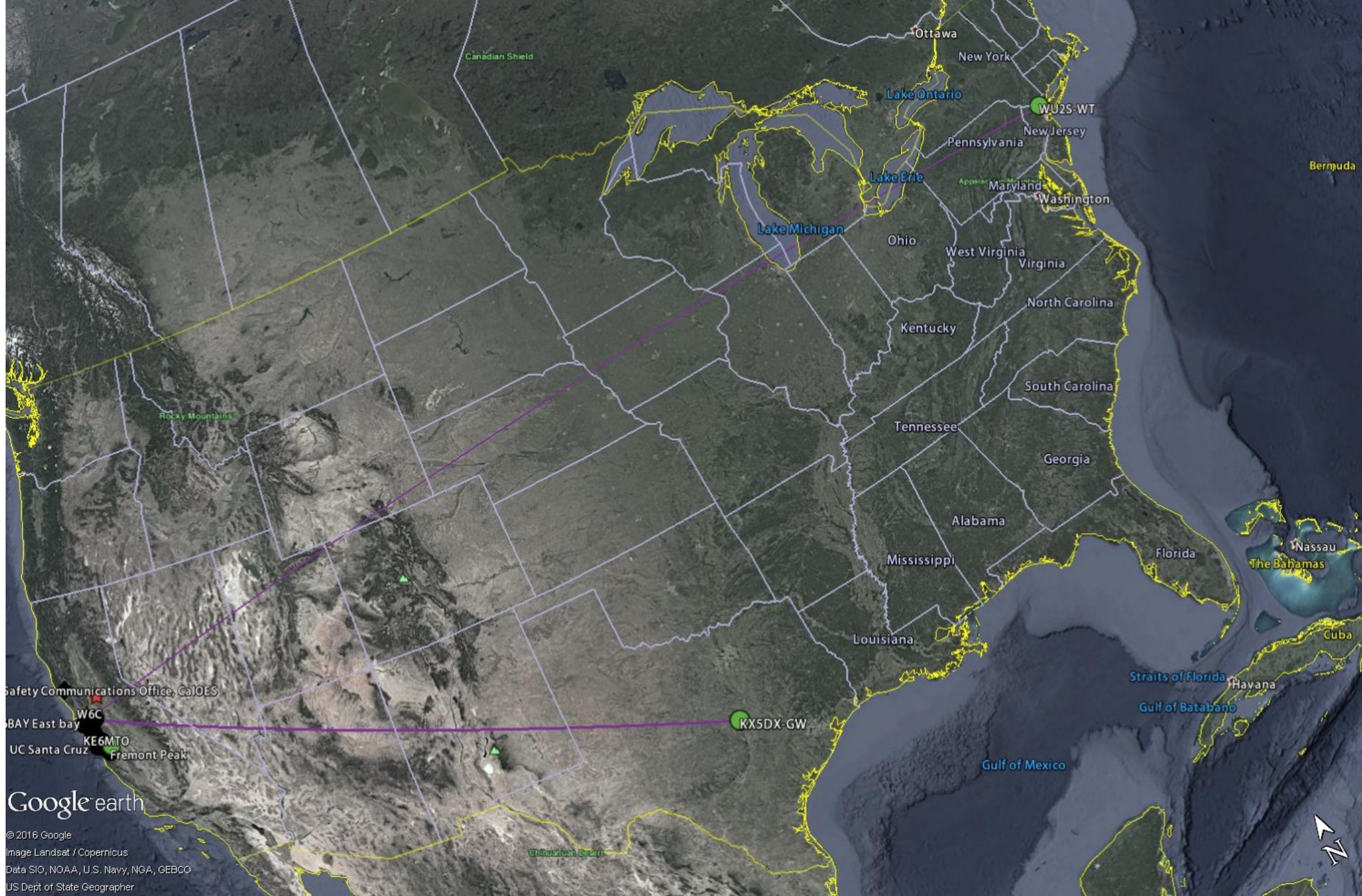


Internet Tunneling

Mesh 1

Mesh 2

Internet



Safety Communications Office, CaIOES
BAY East bay
UC Santa Cruz
KE6MTO
Fremont Peak

Google earth

© 2016 Google
Image Landsat / Copernicus
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
US Dept of State Geographer

Applications that can run on a mesh

- ANY program that runs on a TCP/IP network
- (exceptions: Bandwidth of the RFlink, Multicast traffic, internet access)
- VOIP PBXs (RPi image)
- IRLP, Echolink
- IP cameras (bandwidth allowing)
- Mesh Chat (web based group text chat that runs on the node or RPi)
- Ham chat (web page that runs on the node)
- APRS
- Incident command tickets
- Software defined Radios RX/TX
- Map caching

W6CUS FD 2015 & 2016

portable operation



Trees, Trees, Cranes, Buildings, Not enough elevation

We live in an urban environment.



Potential problems when we establishing site on the mesh



Hubs sites need good coverage!!!

For individual nodes we don't have a ham on every block! We have to do all we can to get our signals to propagate.

-Selecting a site.

Point to point or point to multi point.

-Installing a site

Mounting, RFI, Collocated nodes.

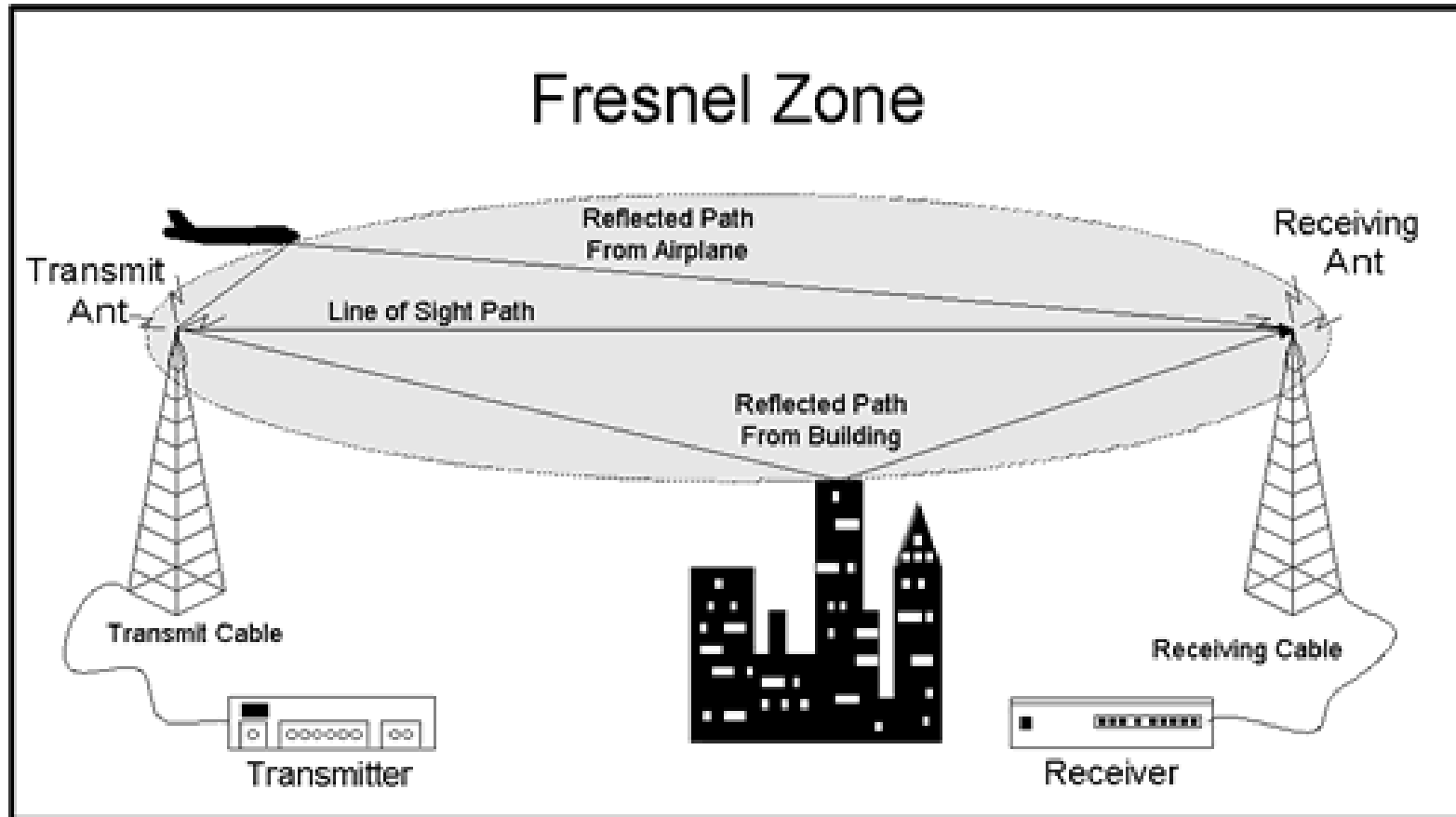


Courtesy of community.ubnt.com



Microwave Propagation

- LOS Line Of Sight & reflections off large surfaces like Buildings!
- I hear you but you don't hear Me.
- Directional Antennas with GAIN!!!! With more gain comes a directional pattern with noise rejection.



Antennas / Effective Power

$$(\text{ transmitter dbm }) + (\text{ Antenna dbi }) = \text{ total dBm}$$

NanostationLOCO M2 (~28dbm) + (NSM2 8dbi) = 36dbm

Nanobridge M2 18dbi dish (~28dbm) + (18dbi) = 46dbm

dBm	Watts		dBm	Watts		dBm	Watts
0	1.0 mW		16	40 mW		32	1.6 W
1	1.3 mW		17	50 mW		33	2.0 W
2	1.6 mW		18	63 mW		34	2.5 W
3	2.0 mW		19	79 mW		35	3.2 W
4	2.5 mW		20	100 mW		36	4.0 W
5	3.2 mW		21	126 mW		37	5.0 W
6	4 mW		22	158 mW		38	6.3 W
7	5 mW		23	200 mW		39	8.0 W
8	6 mW		24	250 mW		40	10 W
9	8 mW		25	316 mW		41	13 W
10	10 mW		26	398 mW		42	16 W
11	13 mW		27	500 mW		43	20 W
12	16 mW		28	630 mW		44	25 W
13	20 mW		29	800 mW		45	32 W
14	25 mW		30	1.0 W		46	40 W
15	32 mW		31	1.3 W		47	50 W

Omni Coverage with some gain

You cant aim what dbm you have.

They have no rejection of noise.

About 500m in range



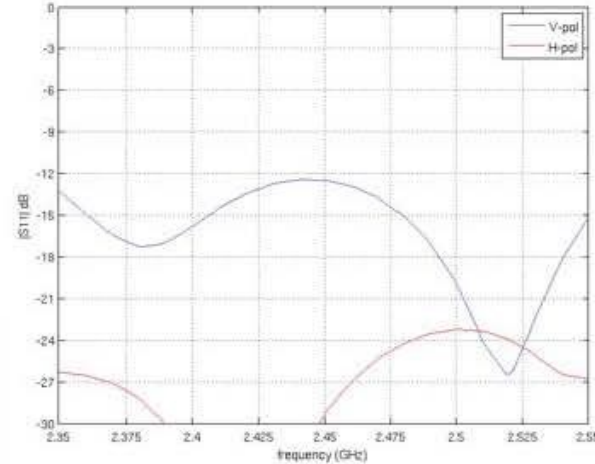
13 dBi

airMAX™ Omni

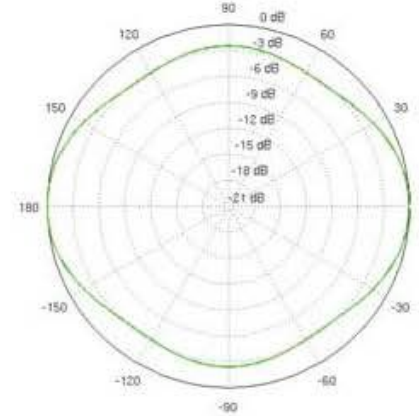
2.4 GHz 2x2 AMO-2G13
Dual Polarity MIMO

AMO-2G10 Antenna Information

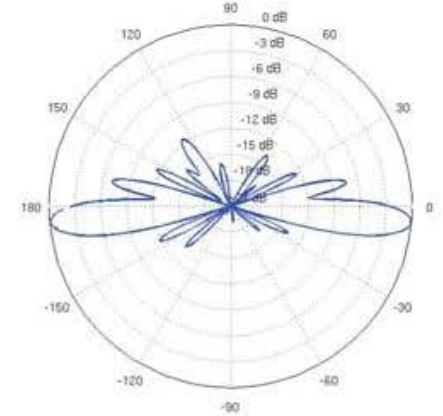
Return Loss



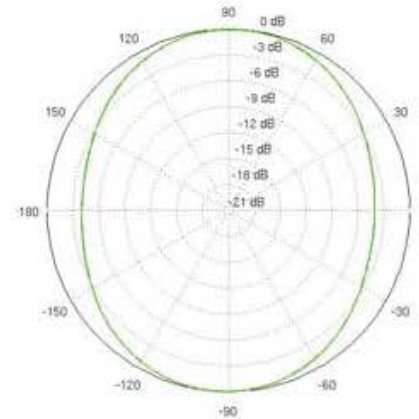
Vertical Azimuth



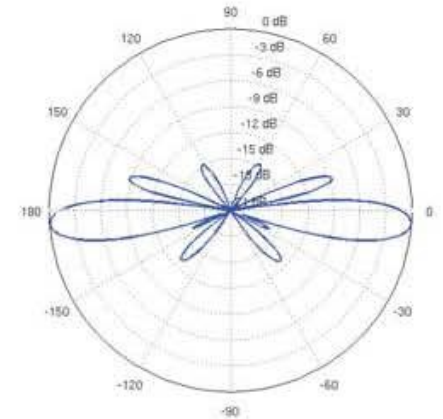
Vertical Elevation



Horizontal Azimuth



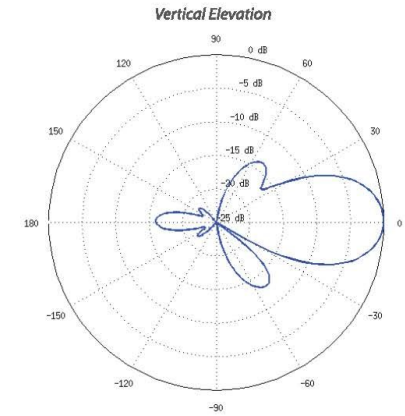
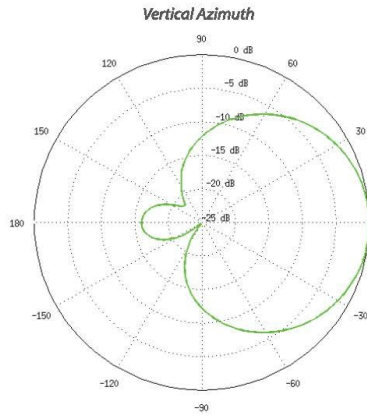
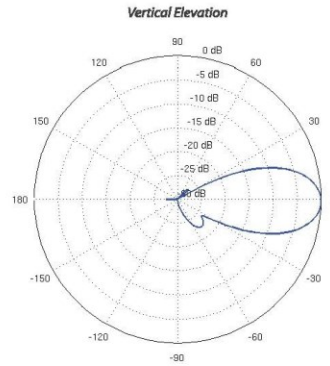
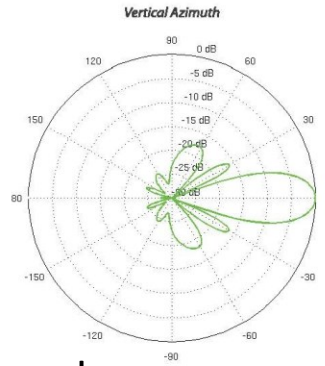
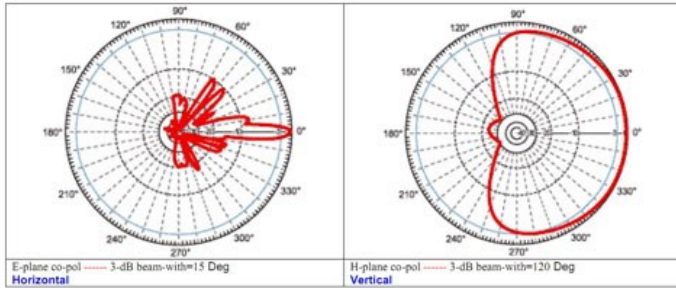
Horizontal Elevation



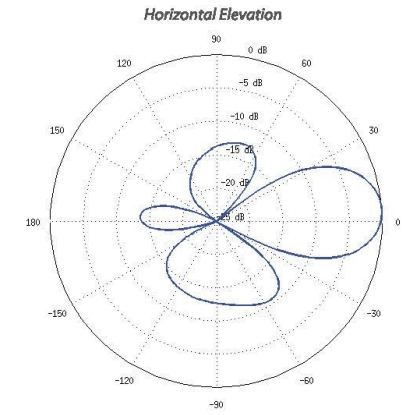
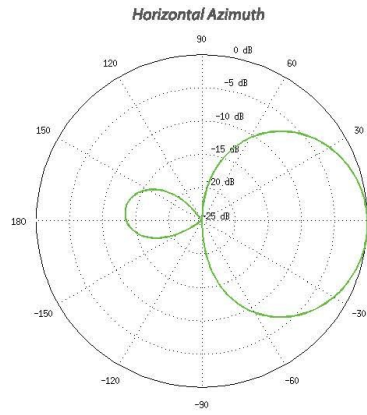
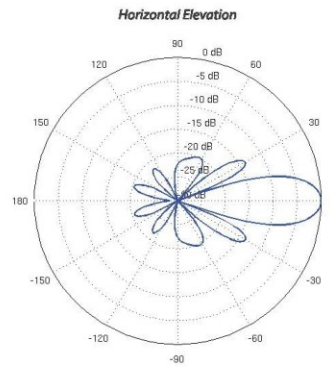
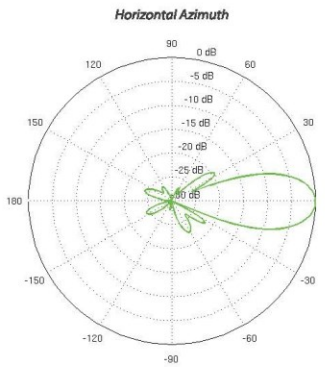
* Dimensions and weight include pole mount and exclude RocketM (RocketM sold separately)

Directional High Gain Antenna

Pattern Test Report



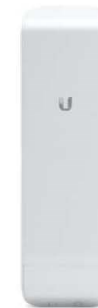
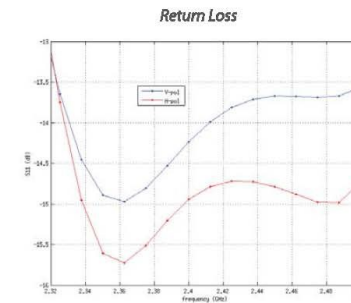
Ubiquity has great self-contained panel antennas. Compared to a WRT54g.



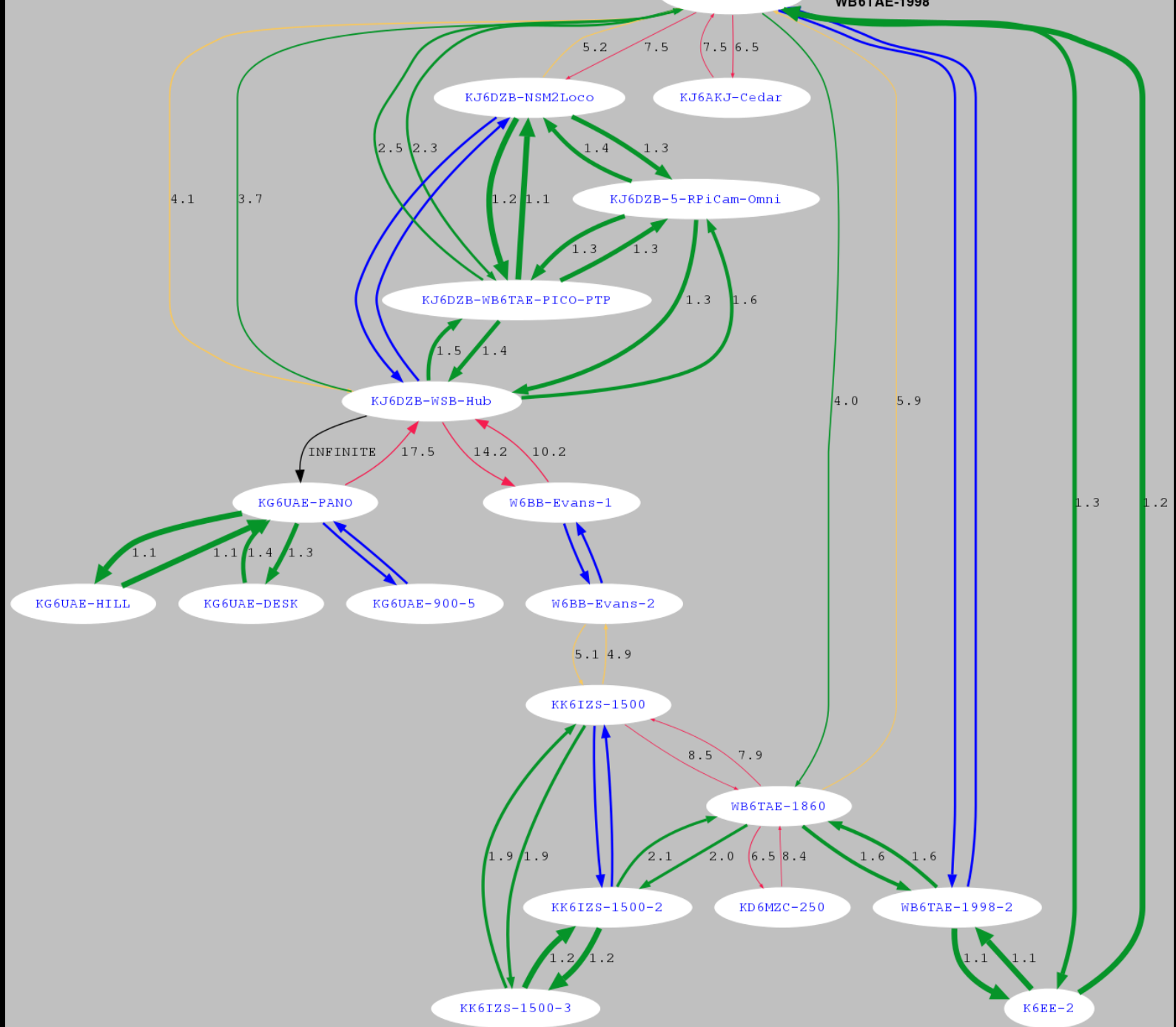
Nanostation Loco : sector coverage, low gain antenna.

Nano Stations : sector antenna, ~11dbi antenna !!

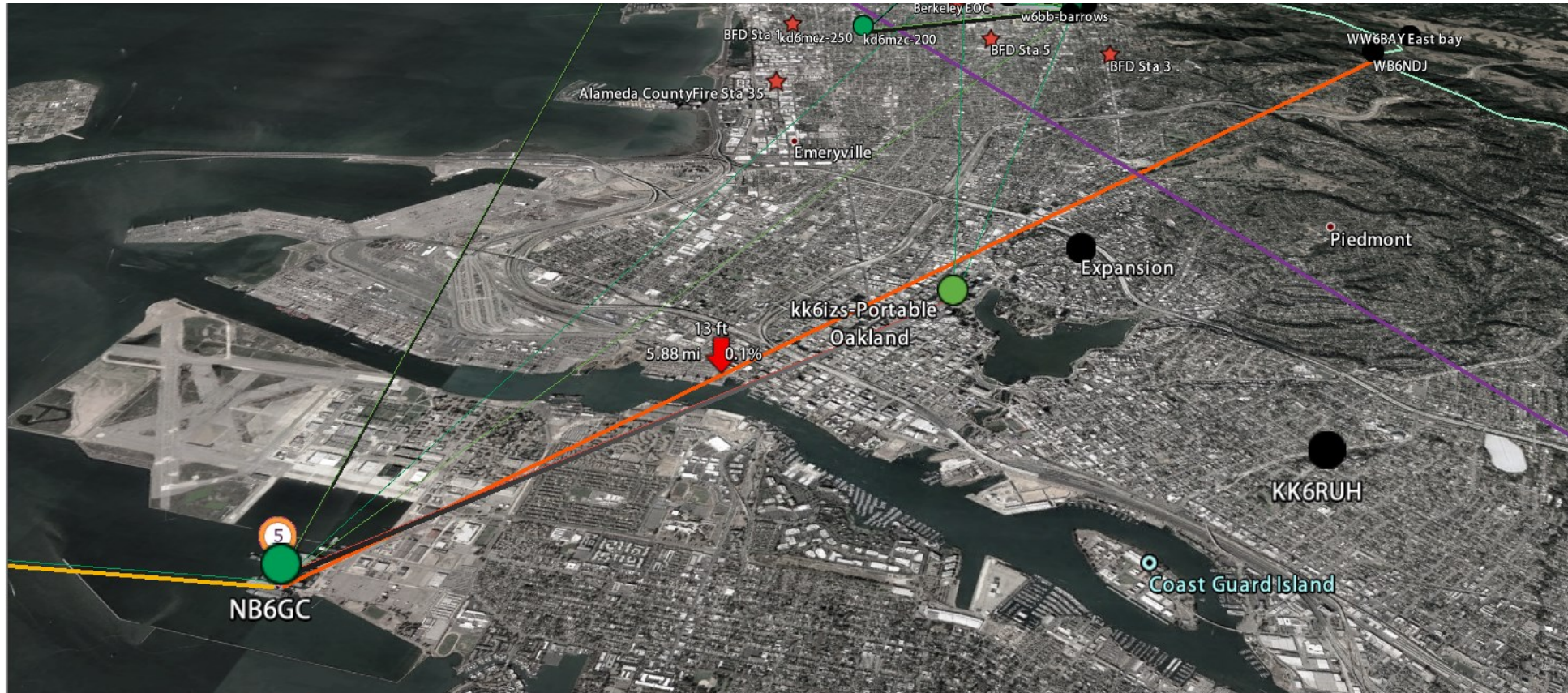
NanoBridge : Beam antenna +18dbi of gain !!



Rockets allows you to pick the antenna that your site needs, it will cost you a bit more.



Google Earth



Graph: Min, Avg, Max Elevation: 0, 249, 1484 ft
Range Totals: Distance: 7.89 mi Elev Gain/Loss: 599 ft, -2084 ft Max Slope: 39.1%, -52.6% Avg Slope: 3.2%, -7.4%



Air Link

<https://airlink.ubnt.com/#/>

airLink | OUTDOOR WIRELESS LINK CALCULATOR | GUI 1.2.18

KPFA-FM Berkeley, Orinda, CA, United States

Golden Gate Fields

12.61 km (link)

LINE OF SIGHT 1ST FRESNEL ZONE 60% CLEARANCE ZONE

AP RX SIGNAL STRENGTH **-75.66 dBm**

1X 2X 4X 6X

MODULATION **64QAM (2/3)**

STA RX SIGNAL STRENGTH **-78.66 dBm**

1X 2X 4X 6X

MODULATION **16QAM (3/4)**

TOTAL CAPACITY **29.58 Mbps**

Enhanced TX Modeling

Frequency: 900 MHz 2.4 GHz 3 GHz 4 GHz 5 GHz 11 GHz 24 GHz

Technology: AIRFIBER AIRFIBER X AIRFIBER FX AIRMAX AIRMAX AC

Channel Width: 10 MHz

ACCESS POINT STATION

Antenna Gain: 11dBi 8dBi

NANOSTATION M900 NANOSTATION LOCO M900

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Live Maps

<https://drive.google.com/open?id=1rfx3IF57xqq0zwwgz0viPZha40kU&usp=sharing>

<http://data.aredn.org/map.kml?>

THE END