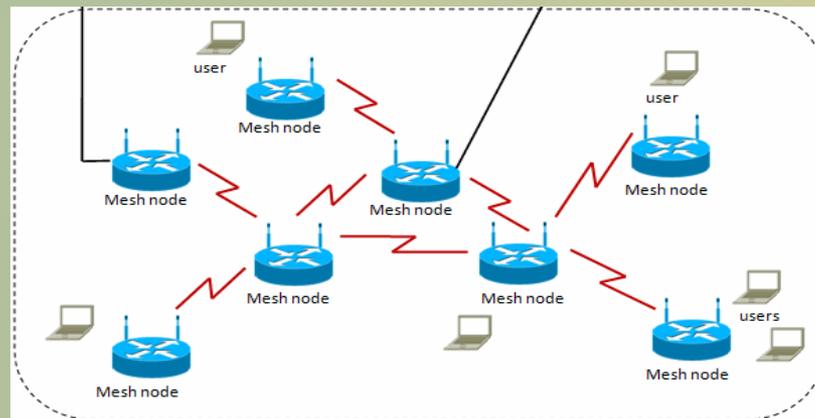# Broadband-Hamnet

Dean Groe, KD4TWJ, April 2014

What is Broadband-Hamnet?

Broadband-Hamnet™ is a network, it is not application software. It is a special firmware build that transforms consumer wireless gear to a specialized ham radio function. It can use application software to transport your data from place to place, but **YOU** must provide the application software just like you do at your home or office.

A Mesh network is a highway over which data travels. Turning on two mesh nodes loaded with Hamnet firmware creates a data network. This highway carries your cargo (data), and allows your local computer to use information or applications stored in other locations.

Mesh nodes were originally consumer wireless routers but changed function when the firmware was changed. After conversion, the WAN, LAN and Wi-Fi ports are linked using special rules and no longer operate like a normal wireless router. Some devices like the Ubiquiti Bullet have only a single network connection. Others like the Linksys WRT54x series have multiple LAN jacks and an Internet jack. All have the RF (WiFi) antenna.

From http://www.broadband-hamnet.org/

What is Broadband-Hamnet?

Formerly known as High Speed Multi-Media (HSMM)-Mesh.

Mesh nodes communicate with other nodes over Wi-Fi frequencies and **only talk to other mesh nodes on the wireless port.**

You **CANNOT** use Wi-Fi to connect <u>directly</u> to a mesh node from your computer, netbook, smart phone or other WiFi capable end user device.

Computers connect to mesh nodes with an Ethernet cable and control them using a web browser.

It is possible to extend a mesh network with a properly restricted WiFi access point (AP) where only hams are given access.

Mesh nodes do not need a computer to be attached to pass data to other mesh nodes. Just plug one in, it will expand the mesh

Mesh nodes will create a network just by turning several of them on. They can be used to create portable, high-speed data networks in minutes

From http://www.broadband-hamnet.org/

What is Broadband-Hamnet?

Mesh nodes normally operate on WiFi channel 1. Channels 1-6 of the 802.11B/G wireless band are completely within the 2.4ghz ham band. As support for additional ham bands is developed, different channels will apply in those bands.

Mesh nodes on channels 1-6 use FCC part 97 rules instead of part 15. This allows big antennas, more power, other changes.

Mesh nodes are **self discovering, self configuring, self advertising and fault tolerant.**

Each node is a router.

Each node builds dynamic routing tables to track which nodes are currently connected to the mesh to enable routing network traffic through the mesh.

If one endpoint cannot see its desired destination, but CAN see nodes in between, the data will hop from one to the next until the final connection is made…. completely automatically.

What is Broadband-Hamnet?

Mesh nodes are small, portable, low-power and inexpensive. They are easily battery powered.

Broadband Hamnet router firmware is available free.

Primary information, download, and forum website is http://www.broadband-hamnet.org/

There are many other Internet resources for information on Broadband-Hamnet.

Amateur Radio 13cm Part 15 overlap

802.11b/g (13 cm)

Channel	Center Frequency	FCC Rules
1	2.412 GHz	Part 97 & Part 15
2	2.417 GHz	Part 97 & Part 15
3	2.422 GHz	Part 97 & Part 15
4	2.427 GHz	Part 97 & Part 15
5	2.432 GHz	Part 97 & Part 15
6	2.437 GHz	Part 97 & Part 15

From ARRL 13cm Bandplan

2410.000-2450.000	22 MHz max bandwidth	Broadband Modes

Amateur Radio 13cm Part 15 overlap

Amateur use of the 2.4Ghz / 13cm mesh channels allows power output up to the following:

❑ 802.11b mode, up to 11 Mbps – This falls within the FCC Part 97.313j Spread Spectrum rules, therefore maximum output power is 10 watts PEP.

❑ 802.11g mode, up to 54 Mbps – uses Orthogonal Frequency Division Multiplexing instead of Spread Spectrum, so Part 97 Spread Spectrum limitations are not applied, therefore maximum output power is 1500 watts PEP.

The 13 cm band is shared with Part 15 users as well as the Federal Radiolocation Service (FCC Part 90.103, Title 47) , and ISM (industrial, scientific, medical) devices. Amateur radio operators have secondary privileges to the Federal Radiolocation Service in the entire band and may not cause interference to these users. Amateur radio operators have primary privileges to ISM devices from 2.390–2.417 GHz and secondary privileges from 2.417–2.450 GHz.

Broadband Hamnet and 802.11 b/g

Each **b** or **g** WiFi channel uses between 20 and 22Mhz of bandwidth, no matter which of the standard throughput speeds is achieved. Whether it is 1 Mbps or 54 Mbps, it still uses 20 - 22Mhz.

The frequencies listed for each channel are the center frequencies.

With a channel bandwidth of 22Mhz, Channels 1 and 6 are the only "non overlapping" channels within the Part 97 Amateur Radio allocation that includes the U.S. 2.4Ghz WiFi channels.

1	2.412 GHz	Part 97 & Part 15
2	2.417 GHz	Part 97 & Part 15
3	2.422 GHz	Part 97 & Part 15
4	2.427 GHz	Part 97 & Part 15
5	2.432 GHz	Part 97 & Part 15
6	2.437 GHz	Part 97 & Part 15

Broadband Hamnet and 802.11 b/g

By default, Broadbad Hamnet nodes always use WiFi channel 1. In part, due to the reasons already discussed.

You should always keep your node(s) configured for channel 1, unless you want to setup some sort of smaller mesh network that is separate from the standard Broadband Hamnet mesh network.

Why 13cm? What a mess!!

Because it is easier to get HAMs to participate. The equipment is more readily available and generally cheaper.

The 5cm, 5.8 Ghz (802.11a) Broadband allocation. It appears that there is work being done on this by the BBHN group. That band has some compelling qualities in certain configurations. It may be supported in the future.

The 9cm, 3.3 – 3.5 Ghz Broadband allocations would probably yield better RF results, simply due to less interference and contention. However equipment choices are much more limited and the price of participation goes up.

The 33cm, 902 – 928 Mhz Broadband allocations also have some possibilities. Once again equipment choices are more limited, and there are a number of other services in that band that compete for that part of the spectrum.

There are HAMs working on integrating some of these other bands into Broadband Hamnet. At some point we may be able to mix equipment on the different bands, depending on the parameters or needs of certain RF environments

Broadband Hamnet firmware

Linksys WRT54Gx routers– The Hamnet firmware divides these devices into three networks, instead of the normal configuration of two networks.

The LAN network can be configured to work in Direct mode, which allows nearly seamless data traffic between it and the Wireless network.

The WAN port is normally firewalled and port forwarding may be necessary.

If you want to connect a Broadband Hamnet node to a LAN that already has Internet connectivity, then you would use the WAN port for that connection, so that you can filter / control that types of traffic that is allowed between the mesh network and the Internet.

If desired, you can disable the WAN or LAN networks on each router.

Linksys WRT54Gx

Broadband Hamnet firmware

Ubiquiti devices – The Hamnet firmware configures supported Ubiquiti devices as two networks, LAN and Wireless. If WAN connectivity is also desired, then another additional switch / router / VLAN is required.

Currently supported Ubiquiti devices include:

- Rocket M2

- Bullet M2 HP

- AirGrid M2 HP

- NanoStation Loco M2 (NSL-M2)

- NanoStation M2 (NS-M2)

More information on Broadband Hamnet and Ubiquiti devices can be found on the Broadband Hamnet website http://www.broadband-hamnet.org/

Ubiquiti Products

http://www.ubnt.com/airmax

After loading Hamnet Firmware

NOCALL

Help   Refresh   Setup   ☐ Night Mode

This node is not yet configured.
Go to the setup page and set your node name and password.
Click Save Changes, <u>even if you didn't make any changes</u>, then the node will reboot.

WiFi/LAN address	172.27.0.1 / 24 fe80::213:10ff:fea0:79d9 Link	**firmware version** **configuration**	1.0.0 not set
WAN address	192.168.0.3 / 24 fe80::213:10ff:fea0:79d9 Link	**system time**	Thu Feb 6 2014 01:45:01 UTC
default gateway	192.168.0.1	**uptime**	2 min
your address	172.27.0.6	**load average**	0.82, 0.62, 0.25
		free space	flash = 4348 KB /tmp = 15208 KB memory = 17808 KB

Initial Broadband Hamnet Setup

Node Status	**Basic Setup**	Port Forwarding. DHCP. and Services	Administration

Help   Save Changes   Reset Values   Default Values   Reboot

Node Name mesh-kd4twj-05   Password _____

Node Type Mesh Node ▼   Verify Password _____

WiFi		**LAN**		**WAN**	
Protocol	Static ▼	LAN Mode	5 host Direct ▼	Protocol	Static ▼
IP Address	10.11.165.30	IP Address	10.93.40.241	IP Address	1▓▓▓▓▓▓
Netmask	255.0.0.0	Netmask	255.255.255.248	Netmask	255.▓▓▓▓▓
SSID	BroadbandHamnet-v	DHCP Server	☑	Gateway	1▓▓▓▓▓▓
Mode	Ad-Hoc ▼	DHCP Start	242	DNS 1	▓▓▓▓▓
Channel	1 ▼	DHCP End	246	DNS 2	▓▓▓▓

Active Settings

Rx Antenna	Right ▼
Tx Antenna	Right ▼
Tx Power	12 dBm ▼
Distance	0

Apply

Mesh Gateway ☐

Let's put it to work!

Many applications that work across other TCP/IP based networks, will also work across a Broadband Hamnet network.

- ✓ Remote radio control (HF radio, Base Station, Repeater, etc...)

- ✓ Voice over IP

- ✓ Messaging (PBBS, Winlink)

- ✓ FTP

- ✓ Video

- ✓ Chat, IRC, etc...

- ✓ Remote session, such as VNC or SSH console.

- ✓ Gateway with RF based Packet systems.

- ✓ Weather Station data.

Accessing services across the Network

Local applications or services can be advertised by the local router to the network. For instance, if a node has an IRC server or Webcam with an embedded Web Server, the node can advertise those services to the network. You would access them with a web browser, in a similar fashion to an Internet WWW page.

The Broadband Hamnet node hosting the service or application can provide a "DNS" type name resolution, like the DNS on the Internet works.

Build the Network

Nodes can be connected to computers or other devices that provide services, such as those listed previously. The connection to the router **from** those devices would be **to** the LAN or WAN port on the node router.

Nodes can simply support the network, providing transmission path and redundancy. All that they need is power. A computer connection is not required. Analogous to an APRS Digipeater that is not connected to a computer, or providing additional data to the network, but simply supporting the network.

Internet Point to Point Tunnels using the Generic Routing Encapsulation (GRE) protocol can be setup between nodes or geographically separated networks to fill-in areas that do not have connections between them. This is not a "when all else fails" EmComm solution, but it still adds value to the network.

Antenna Systems

Propagation ranges beyond about five hundred feet require clear line of sight and high gain antennas. Typical range with a clear path, antennas with 15dbi to 24dbi gain, and assuming very little antenna feed line loss, is around three to five miles.

WiFi antenna gain figures are usually listed at the dbi reference... Higher sales literature numbers.

Even high gain vertical antennas will have shorter range than directional antennas.

Typical radiated WiFi power level from a Linksys WRT54x router is about 65 Milliwatts with standard antennas, but can be increased to almost 100 Milliwatts with the Broadband Hamnet firmware.

Some Ubiquiti devices can provide between 500 and 1000 Milliwatts of output power.

Feed line loss can be significant at 13cm wavelengths, and higher.

COAX loss in db at 2.4Ghz / 13 cm

| Cable Type	10 Feet	25 Feet
RG-58	3.3	8.25
RG-8X	2.3	5.75
LMR-240	1.3	3.25
RG-213/214	1.5	3.75
9913 Air Dialectric	.8	2.0
LMR-400	.7	1.75
LMR-600	.45	1.1

WiFi antenna distance calculation

TP-Link has a link distance / antenna calculator that can be interesting to use. You would need to look at their device model specifics and then choose the proper devices to simulate the link criteria that you want to test for.
http://www.tp-link.us/Support/Calculator/#4

Other factors to consider that are not part of the calculator, include topography between each point, and obstructions, such as buildings or maybe large signs. Fresnel Zone can be a factor also. More on that in a minute.

There are various topography map resources available on the Internet, and Google Earth also has a basic topography model that you can view.
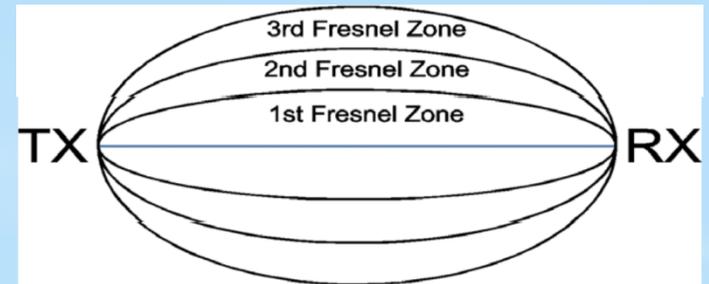
Fresnel Zone
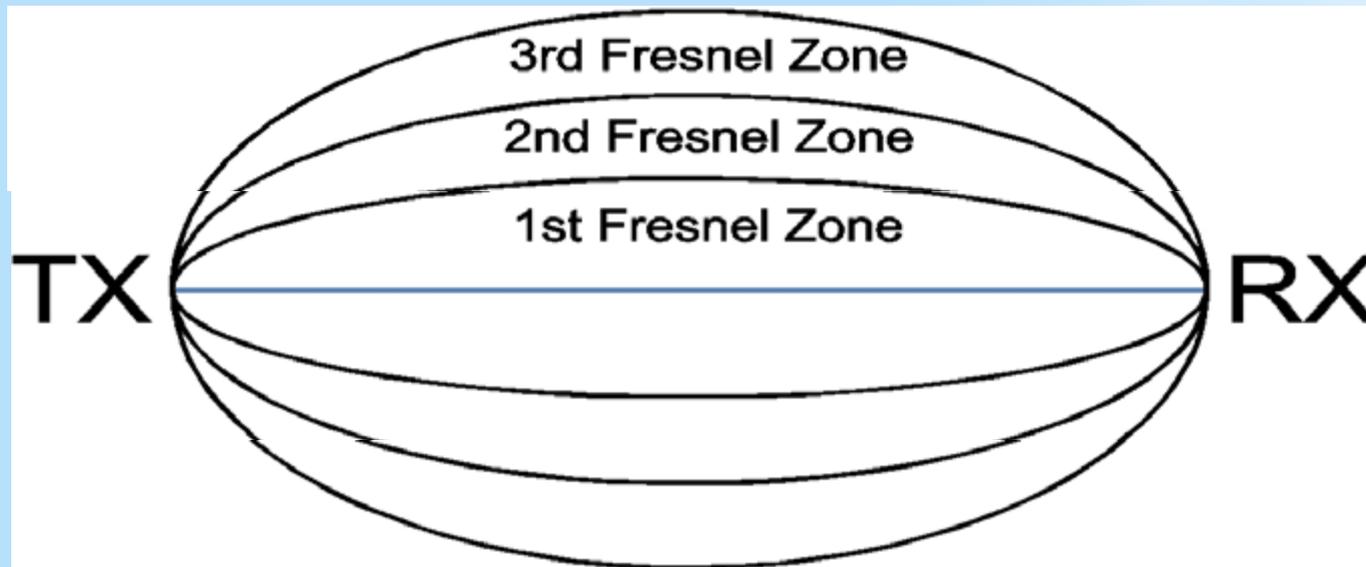
Obstacles in the area around the visual line-of-sight that radio waves spread out into after they leave the antenna may cause the received signal strength to be affected.

These obstacles could be buildings, vegetation, water, or even the ground. This area is called the Fresnel Zone.

From presentation by KE6TIM.

Fresnel Zone

• Each Fresnel zone is an ellipsoidal shape.

• Deflections from obstacles which occur anywhere in zone 1 will, if they arrive at the RX, create signals that will be 0 to 90 degrees out of phase.

• In zone 2 they will be 90 to 270 degrees out of phase.

• In zone 3 they will be 270 to 450 degrees out of phase and so on.

• Even numbered zones can degrade signal (they have the maximum **phase cancelling** effect) and odd numbered zones can enhance signal (they may actually add to the signal power).

• The signal strength (and hence the magnitude of the **phase cancelling** effect) is strongest in zone 1 and decreases in each successive zone simply because wave paths get longer (and signals get weaker) the further they are from the direct line from transmitter to receiver.

From presentation by KE6TIM.

Fresnel Zone

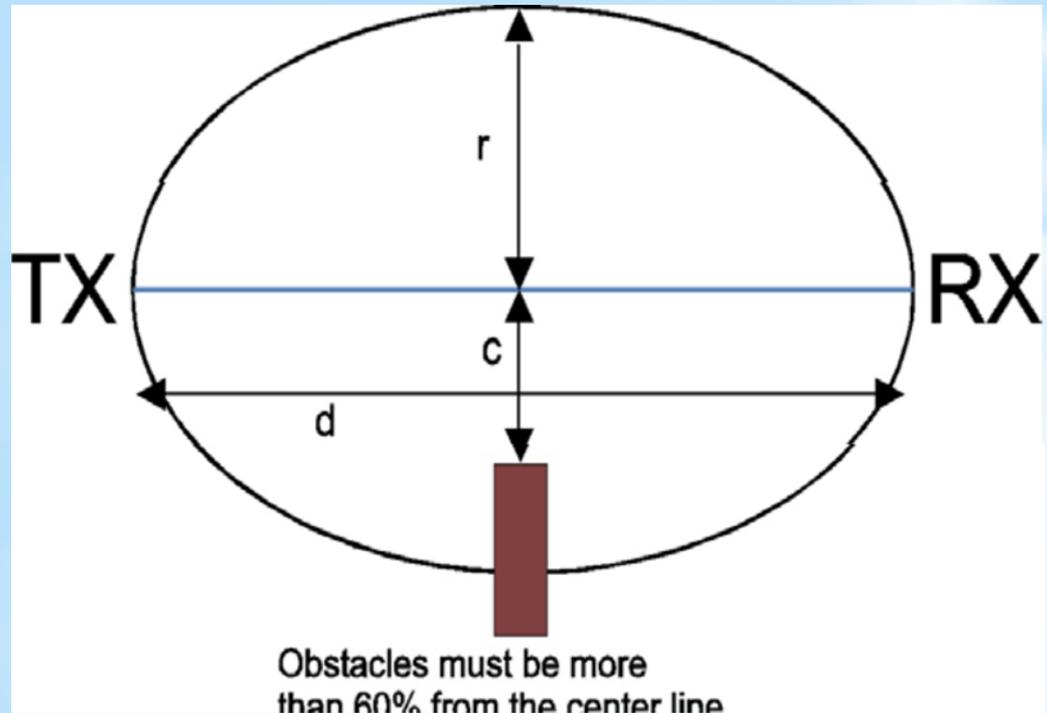- The radius of the first zone can be calculated

$$r \sqrt{\frac{D}{f}}$$

r = radius in feet
D = total distance in miles
f = frequency transmitted in GHz.

- The rule of thumb is that 60% of the 1st Fresnel zone must be clear of obstacles.

- Example: If r is 20',
c must be at least 12'.

TX · RX

r

c

d

Obstacles must be more
than 60% from the center line

- On-line calculator:
http://www.wirelessconnections.net/calcs/FresnelZone.asp

From presentation by KE6TIM.

Demo