HSMM-Mesh ™

SeaPac 2-Jun-2012

Scott Scheirman AD7XV

Why do we want fat pipes?

- Msg 322, Jan 1, 2014
- From: NORTH_CTY
- To: EOC
- Message:
- Tower has ice on it, may affect signals
- End of message

HSMM-Mesh: Agenda

- Welcome, intro, credits, disclaimer
- History
- What is it, what can I do with it?
- Client software
- Frequencies, how far will it go?
- The Hardware
- How do I get started?
- Demo
- Resources
- Q&A

Credits

Jim K5KTF
Hsmm-mesh website
Jim@k5ktf.com

Glenn Currie KD5MFW
Hsmm-mesh designer

kd5mfw@arrl.net

John Champa, K8OCL
Silent Key, Oct 2010
Original ARRL HSMM
Working Group Leader

Gary Takis, K7GJT
Many slides from Gary

HSMM-Mesh™ Disclaimer

- Fluent in TCP/IP networking, or a “self-starter”
  - Establish a local ‘mesh group’?
- Not a mature product
- May or may not fit your application
- You can “brick” your router
  - Then again it is only $50 or so
- Be aware of RF exposure safety
  - 20 dB antenna + 5 watt amplifier = 500 W ERP (!!!)
- Great low-cost way to have fun with ham radio

HSMM-Mesh™ History

- Drivers:
  - Rapid growth of consumer grade Wi-Fi devices
  - Channels 1-6 of the FCC Part 15 802.11B/G wireless band are completely within the FCC Part 97 2.4Ghz ham band
  - Need for high speed data links for emcomm
- Add: Some very clever hams
- Results:
  - 2001 -- Started out as “ARES-MESH”
  - ARES is an ARRL trademark!
  - Now HSMM-MESH™

HSMM-Mesh – what is it?

- "**H**igh **S**peed **M**ulti-**M**edia **Mesh**"
- High-speed, self-discovering, self configuring, fault tolerant Ham radio wireless network.
- 13 cm amateur band overlaps 2.4 GHz Wi-Fi band
- Use off-the-shelf, inexpensive hardware
- Update the firmware

PACKET	**1.2Kb/sec** or **9.6Kb/sec**
802.11b wireless routers	**10 Mb/sec**
802.11g wireless routers	**54 Mb/sec**

What can we do with HSMM-Mesh?

- Connect TCP/IP devices over the mesh:
  - Computer
  - Webcam
  - VoIP phone
  - Server
- provide internet access to the entire HSMM-Mesh network
- EOC to Agency link, Emergency “traffic”, field day, fun

Client Software

- Filezilla for file transfer
- ChatZilla for IM chatting
- Video
- Voice over IP (VoIP)
- IRC

- *Whatever works across a normal Wi-Fi net!!*
- *Some of this can operate inside the router!!*

Frequencies & Power

HSMM 802.11(a),(b),(g) under FCC Part 97.311

802.11(a) 12 Channels Non-Overlapping

5.650 – 5.925 GHz OFDM 1500 W PEP

802.11(b) 8 Channels Overlapping

2.390 – 2.450 GHz DSSS **10 W PEP**

802.11(g) 8 Channels Overlapping

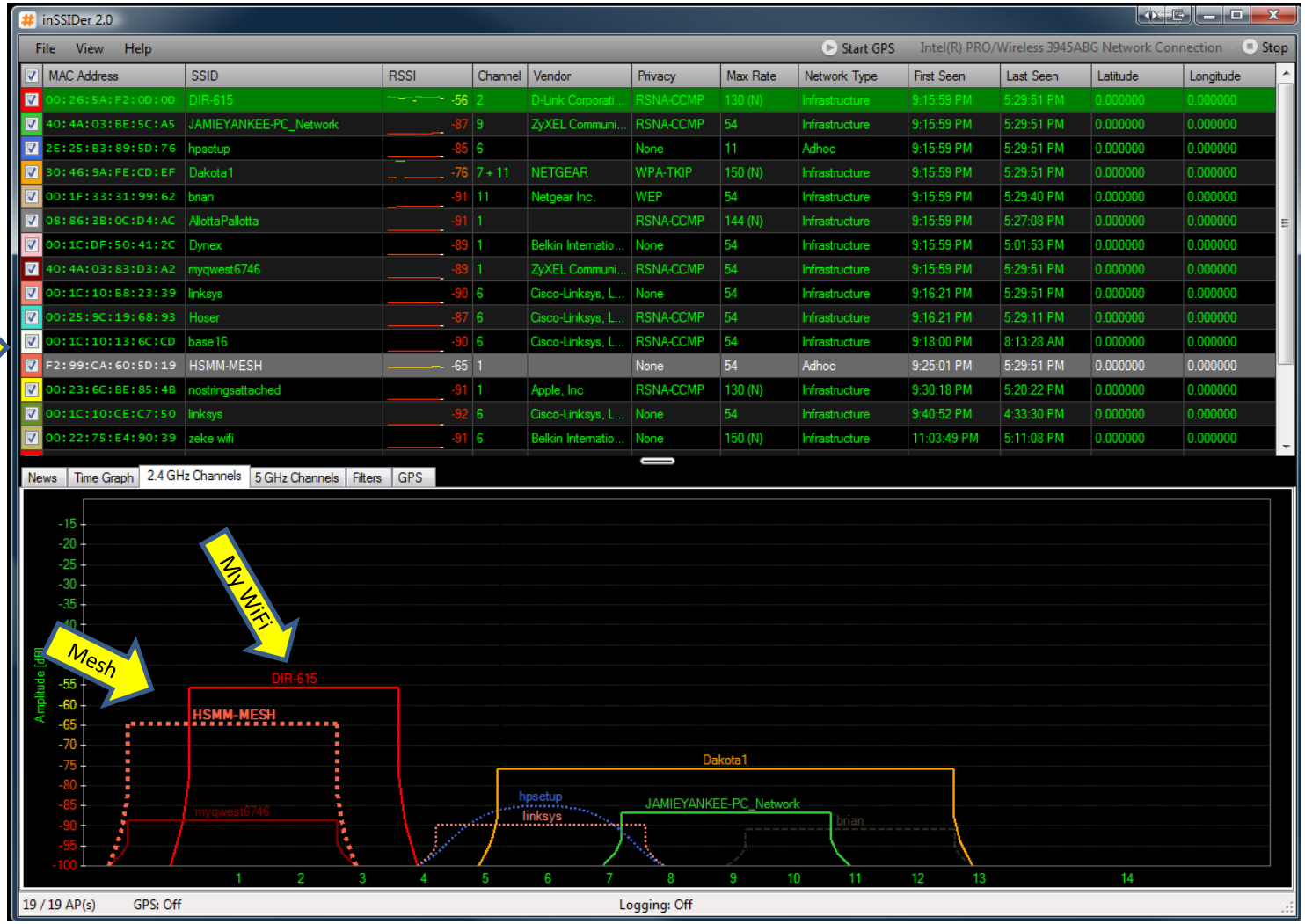
2.390 – 2.417 GHz OFDM **1500 W PEP**

OFDM : Orthogonal Frequency Division Multiplexing

DSSS : Direct Sequence Spread Spectrum

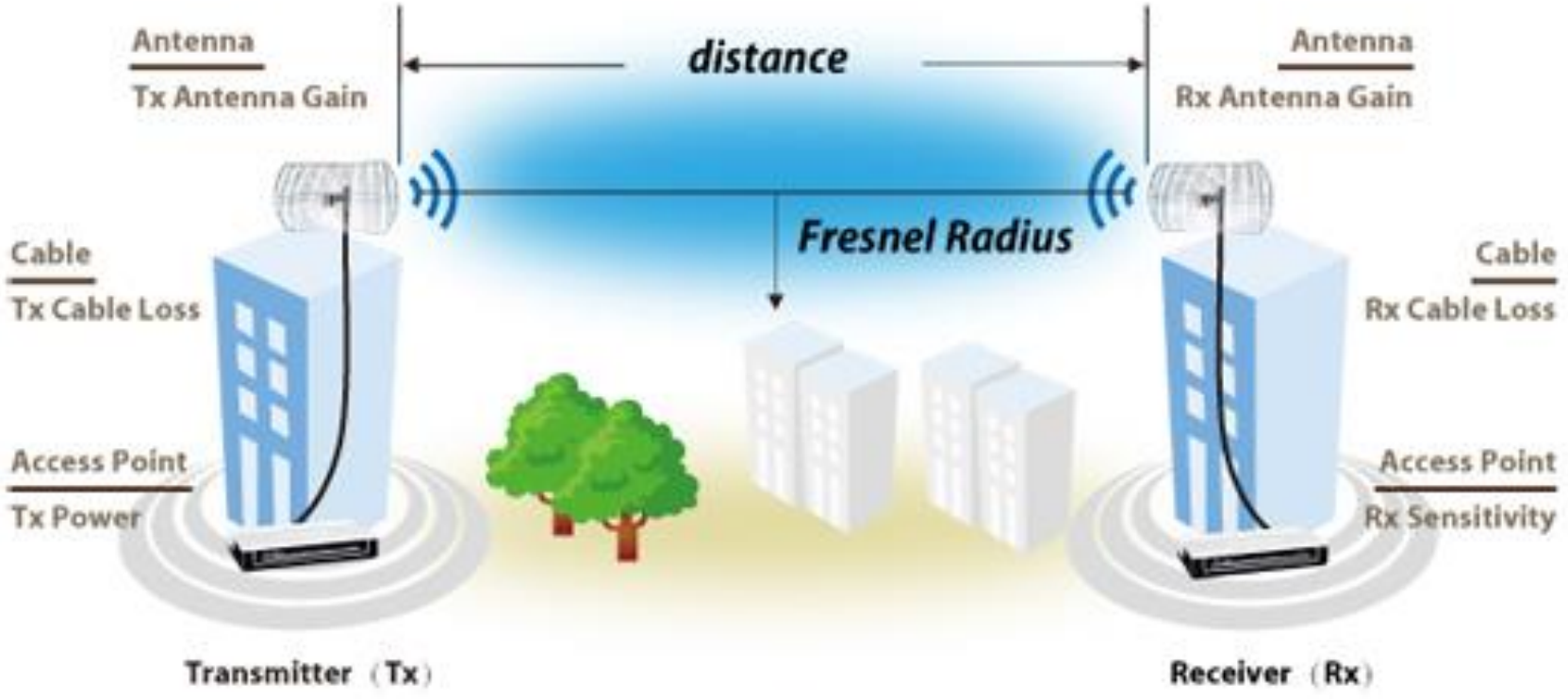
Uses Ch 1 of the 802.11 WiFi band

Using “inSSIDer”



Mesh

How far will it go?



“stock: Wi-Fi design max is 100 meters.
10 mi achieved in TX with dish antennas and elevation

http://www.tp-link.com/en/support/calculator/

Keep the antenna cable short!

Cable	Diameter	Loss (db/100ft)	Loss (% / 6 feet)
RG-174	0.1”	75 dB	94%
LMR-100	0.1”	39.8 dB	78%
RG-58A/U	0.2”	38.9 dB	78%
LMR-200	0.2”	16.5 dB	47%
LMR-400	0.4”	6.6 dB	22%
LMR-600	0.6”	4.4 dB	15%

The Hardware

- Router: LinkSys WRT-54G Series
  - 12VDC @ <1A
  - Uses “RP-TNC” antenna connector
- Antenna Options Below
  - Typically Use ‘RP-SMA’ and ‘N’ connectors
- Bi-directional amplifiers available

Circular, Rectangular or Flat Panel = 8-24Dbi

12 El beam = 20Dbi
16 El beam = 24DBi

Verticals
8 Dbi
12 Dbi
15 Dbi

What about Power?

- WRT54G wireless router: 12VDC @ < 1A
- Accessories (e.g. IP Cam): maybe 5 V DC @ 2 A
- AC Power Supply
- Battery
- Solar
- PoE (“Power over Ethernet”)
  - *Mode A: power on the data pairs*
  - *Mode B: power on the spare pairs.*

Typical Commercial PoE device

TP-LINK®

Power over Ethernet Adapter Kit

TL-POE200

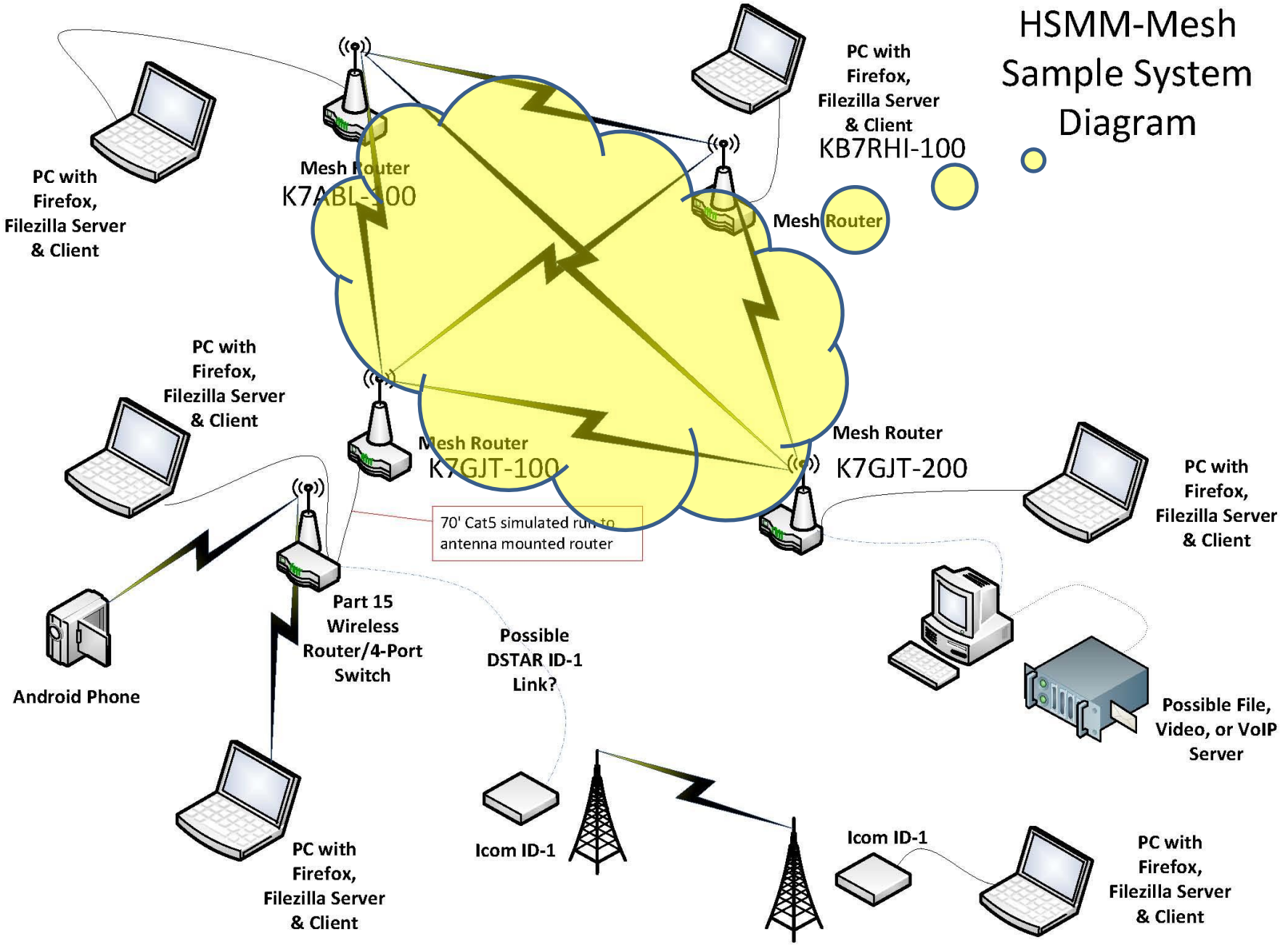
Voltage Output	DC 5V, 9V or 12V
Output Power	12V/1A, 9V/1.2A, 5V/2.3A

Unidirectional

Omnidirectional

HSMM-Mesh in a Backpack

HSMM-Mesh in a box


HSMM-Mesh
Sample System
Diagram
PC with
Firefox,
Filezilla Server
& Client
Mesh Router
K7ABL-100
PC with
Firefox,
Filezilla Server
& Client
KB7RHI-100
Mesh Router
PC with
Firefox,
Filezilla Server
& Client
Mesh Router
K7GJT-100
Mesh Router
K7GJT-200
PC with
Firefox,
Filezilla Server
& Client
70' Cat5 simulated run to
antenna mounted router
Android Phone
Part 15
Wireless
Router/4-Port
Switch
Possible
DSTAR ID-1
Link?
Possible File,
Video, or VoIP
Server
PC with
Firefox,
Filezilla Server
& Client
Icom ID-1
Icom ID-1
PC with
Firefox,
Filezilla Server
& Client

HSMM-Mesh How do I get started?

1. Get a router (thrift, on-line) (watch serial numbers!)
2. Update (reflash) router firmware
3. Get within range of another router
4. You are connected!

DEMO TIME!

Upgradable	Serial # prefix
WRT54G	CDF0 to CDFA
WRT54GS	CGN0 to CGN6
WRT54GL	CL7A to CF7A

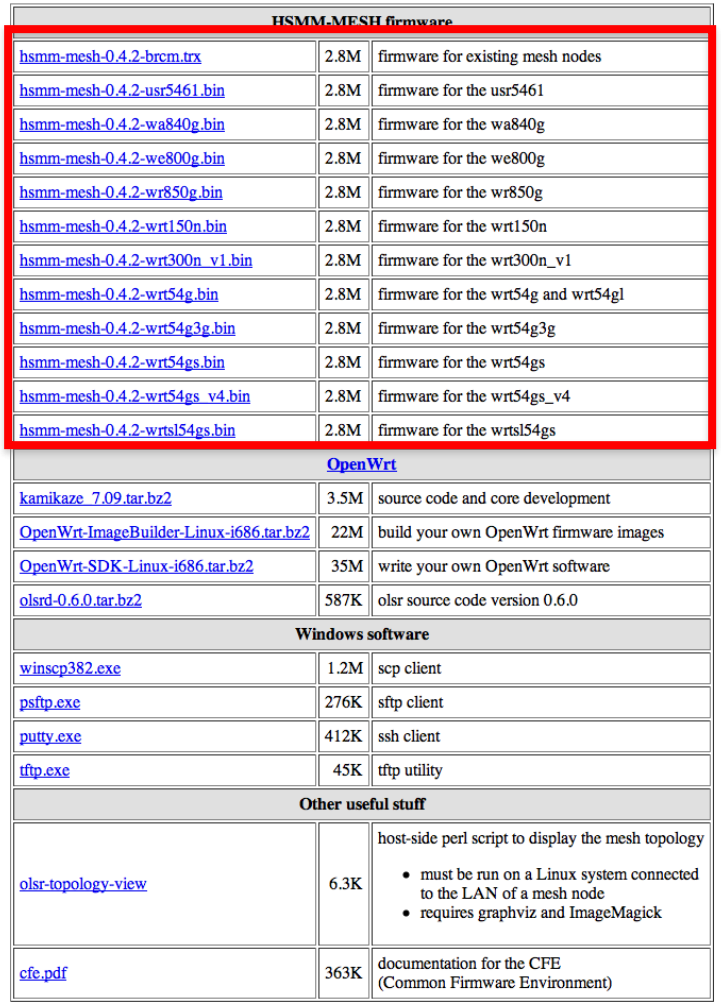
Not upgradable	Serial # prefix
WRT54G	CDFB to CDFG CDFJ, CDFK, MDF0
WRT54GS	CGN7 to CGNC, CGNE

Complete list is here:
http://hsmm-mesh.org/images/hsmm_docs/wrt54xx%20shopping%20guide.pdf

Program the router

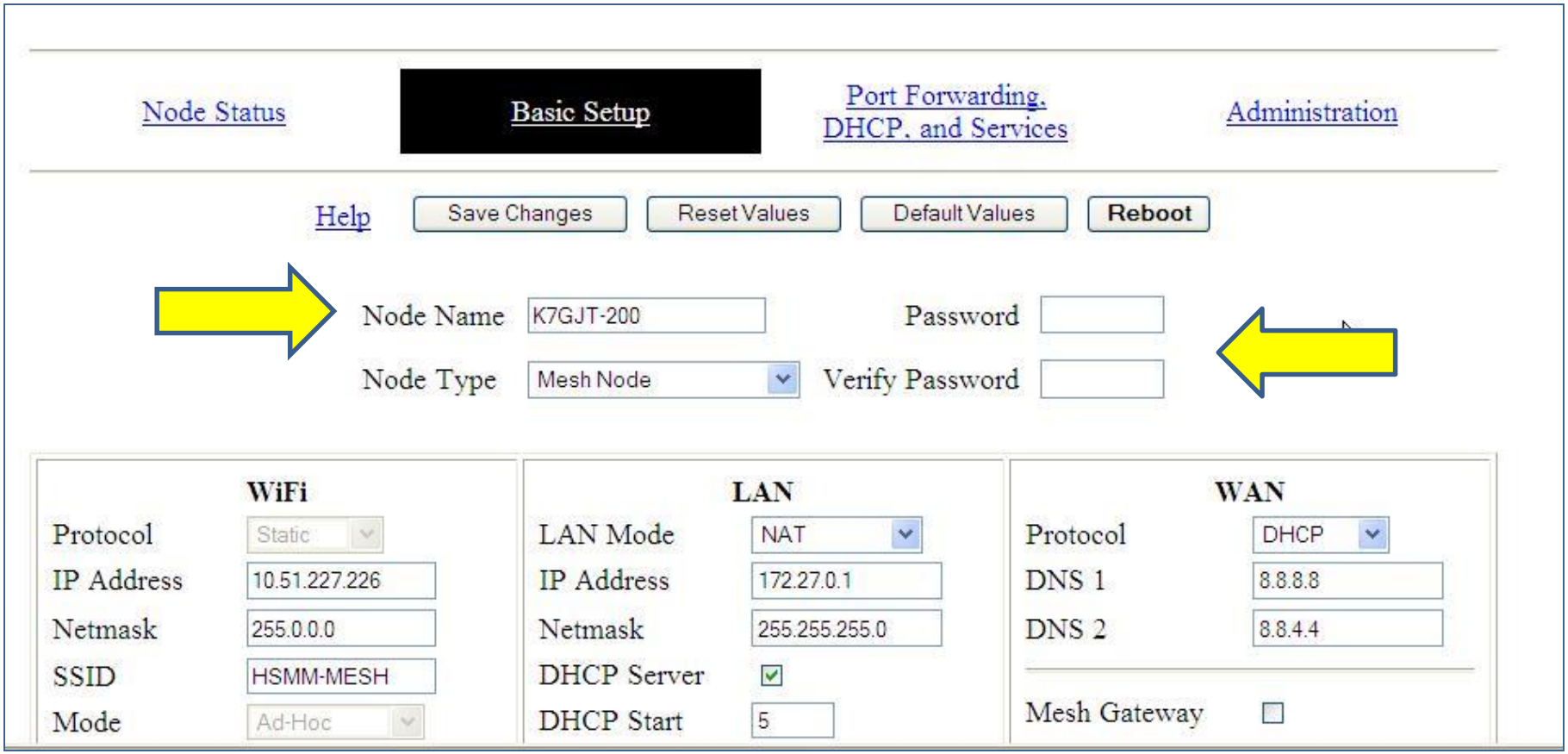
1. Get the firmware
2. Update the router
3. Reboot the router
4. Log-in to the new mesh node
5. Give it a node name (AD7XV-100)
6. Change the password
7. Save and reboot
8. Get within range of another router
9. You are connected!

DEMO TIME!

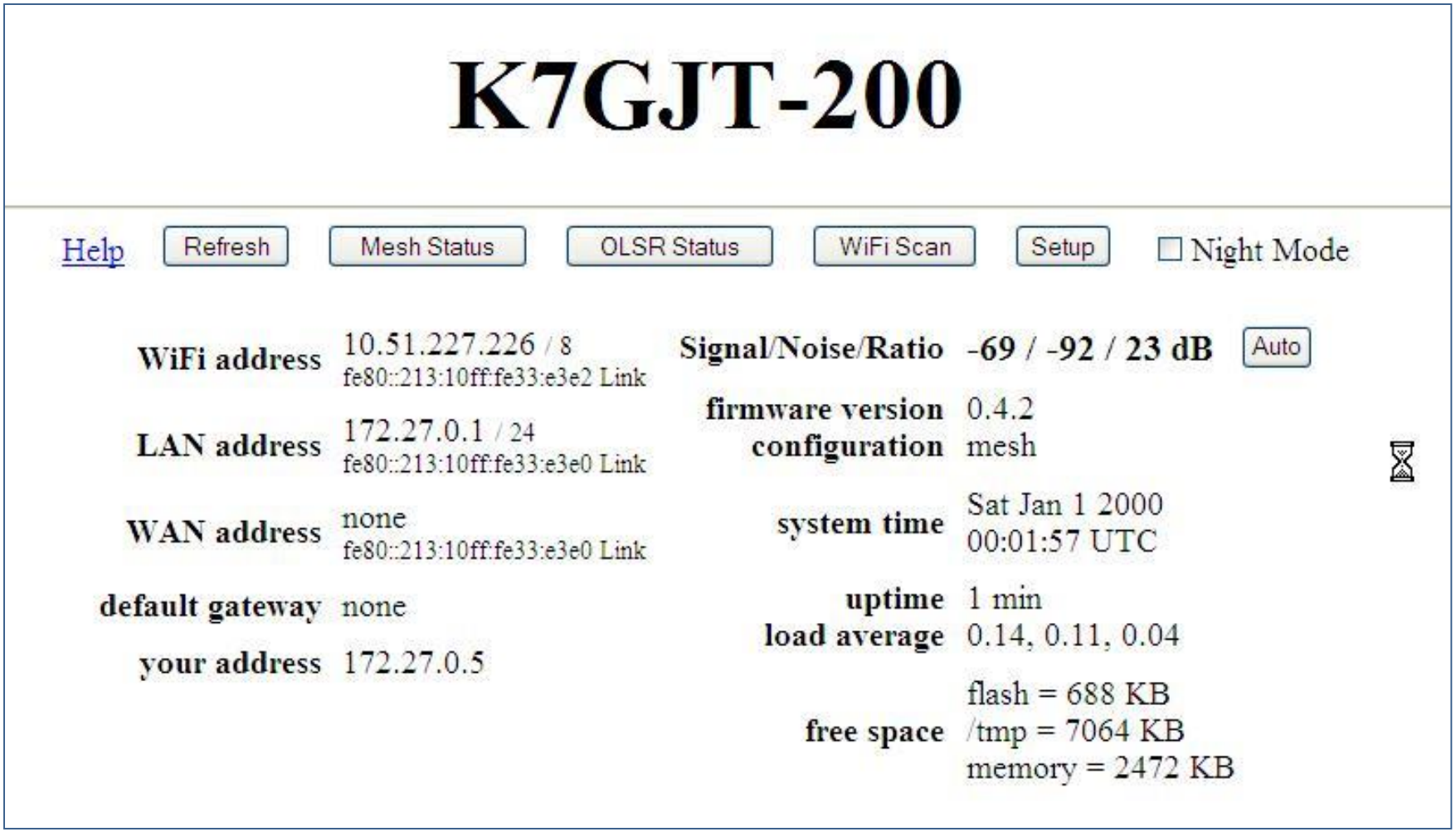


HSMM-MESH firmware		
hsmm-mesh-0.4.2-brcm.trx	2.8M	firmware for existing mesh nodes
hsmm-mesh-0.4.2-usr5461.bin	2.8M	firmware for the usr5461
hsmm-mesh-0.4.2-wa840g.bin	2.8M	firmware for the wa840g
hsmm-mesh-0.4.2-we800g.bin	2.8M	firmware for the we800g
hsmm-mesh-0.4.2-wr850g.bin	2.8M	firmware for the wr850g
hsmm-mesh-0.4.2-wrt150n.bin	2.8M	firmware for the wrt150n
hsmm-mesh-0.4.2-wrt300n_v1.bin	2.8M	firmware for the wrt300n_v1
hsmm-mesh-0.4.2-wrt54g.bin	2.8M	firmware for the wrt54g and wrt54gl
hsmm-mesh-0.4.2-wrt54g3g.bin	2.8M	firmware for the wrt54g3g
hsmm-mesh-0.4.2-wrt54gs.bin	2.8M	firmware for the wrt54gs
hsmm-mesh-0.4.2-wrt54gs_v4.bin	2.8M	firmware for the wrt54gs_v4
hsmm-mesh-0.4.2-wrtsl54gs.bin	2.8M	firmware for the wrtsl54gs
OpenWrt		
kamikaze_7.09.tar.bz2	3.5M	source code and core development
OpenWrt-ImageBuilder-Linux-i686.tar.bz2	22M	build your own OpenWrt firmware images
OpenWrt-SDK-Linux-i686.tar.bz2	35M	write your own OpenWrt software
olsrd-0.6.0.tar.bz2	587K	olsr source code version 0.6.0
Windows software		
winscp382.exe	1.2M	scp client
psftp.exe	276K	sftp client
putty.exe	412K	ssh client
tftp.exe	45K	tftp utility
Other useful stuff		
olsr-topology-view	6.3K	host-side perl script to display the mesh topology • must be run on a Linux system connected to the LAN of a mesh node • requires graphviz and ImageMagick
cfe.pdf	363K	documentation for the CFE (Common Firmware Environment)

Router Basic Setup



Node Status


K7GJT-200
Help
Refresh
Mesh Status
OLSR Status
WiFi Scan
Setup
Night Mode
WiFi address
10.51.227.226 / 8
fe80::213:10ff:fe33:e3e2 Link
LAN address
172.27.0.1 / 24
fe80::213:10ff:fe33:e3e0 Link
WAN address
none
fe80::213:10ff:fe33:e3e0 Link
default gateway
none
your address
172.27.0.5
Signal/Noise/Ratio
-69 / -92 / 23 dB
Auto
firmware version
0.4.2
configuration
mesh
system time
Sat Jan 1 2000
00:01:57 UTC
uptime
1 min
load average
0.14, 0.11, 0.04
free space
flash = 688 KB
/tmp = 7064 KB
memory = 2472 KB

Mesh Status

My Portable Station

My QTH Station

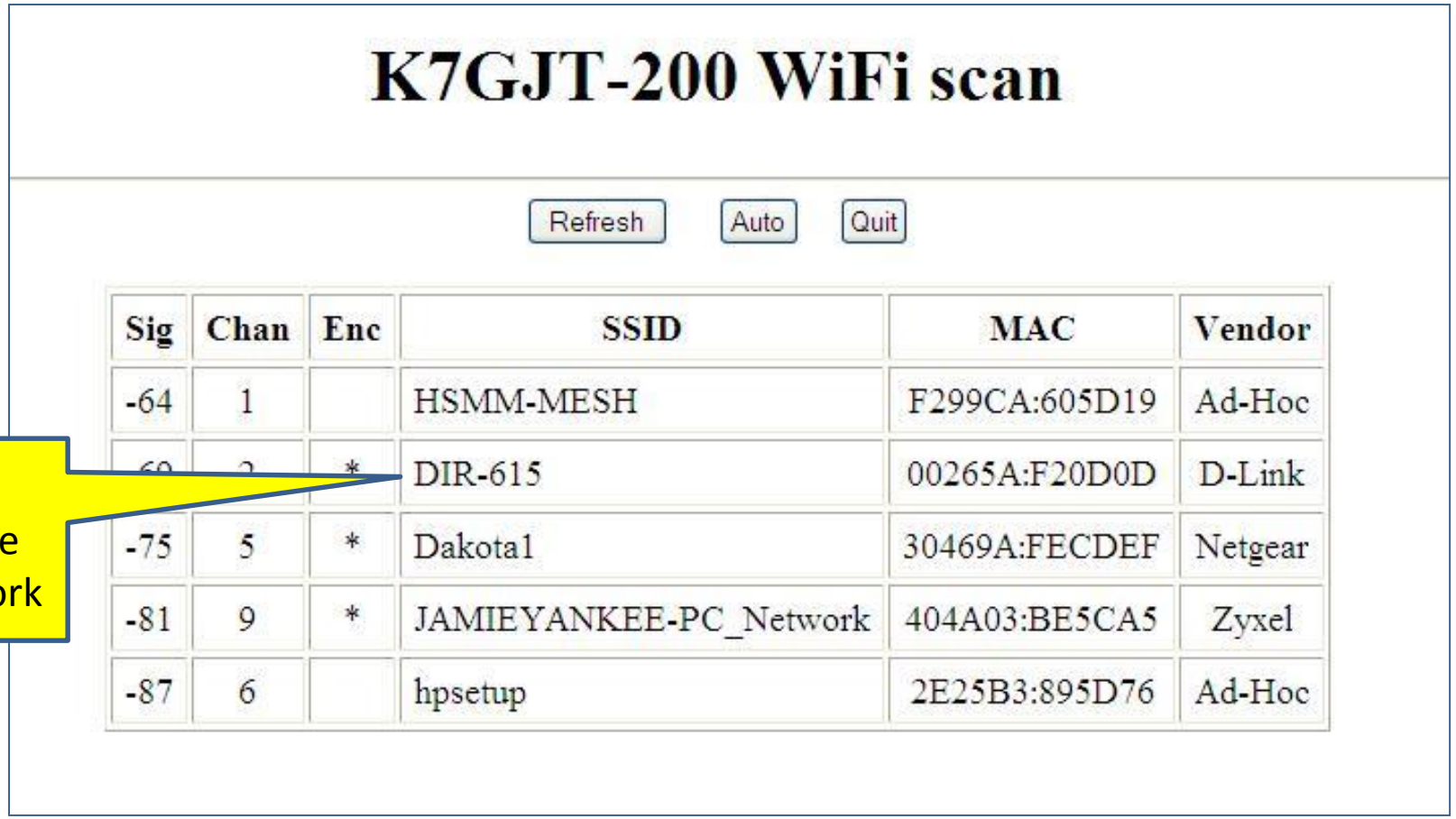
K7GJT-200 mesh status

Refresh Auto Quit

Local Hosts	Services	Current Neighbors	LQ	Services
K7GJT-200		K7GJT-100	94%	

Remote Nodes	ETX	Services	Previous Neighbors	When
none			none	

WiFi Scan



K7GJT-200 WiFi scan

Refresh Auto Quit

Sig	Chan	Enc	SSID	MAC	Vendor
-64	1		HSMM-MESH	F299CA:605D19	Ad-Hoc
[illegible]	[illegible]	*	DIR-615	00265A:F20D0D	D-Link
-75	5	*	Dakota1	30469A:FECDEF	Netgear
-81	9	*	JAMIEYANKEE-PC_Network	404A03:BE5CA5	Zyxel
-87	6		hpsetup	2E25B3:895D76	Ad-Hoc

HSMM-Mesh – key facts

- High-speed, self-discovering, self configuring, fault tolerant Ham radio wireless network.
- Provides a high-bandwidth “pipe” for amateur radio data
- Extend range with aftermarket (gain) antennas
- Keep antenna cable runs short
- Great way to learn about networking
- Uses include emergency “traffic”, network connectivity if public internet goes out or is unavailable
- Fun

ARRL QST & QEX Articles

- QEX Jan 2011 (Pg. 2) – HSMM Losses
- QST Nov 2006 (Pg. 96) – Non-traditional Field Day? You Bet! (HSMM)
- QEX Jan 2005 (Pg. 61) – HSMM Radio Equipment (Nov/Dec 2004)
- QEX Nov 2004 (Pg 3) – HSSM Radio Equipment
- QST Dec 2004 (Pg 21) – Bit bucket aids HSMM experiment
- QST Apr 2003 (Pg 28) – High Speed Multimedia Radio
- QST Apr 2003 (Pg 31) – Using APRS to Locate Amateur HSMM Stations
- QST May 2003 (Pg 24) – More on HSMM Radio

HSMM Resources

- main site www.HSMM-MESH.org
- Which routers will work?

  http://hsmm-mesh.org/images/hsmm_docs/wrt54xx%20shopping%20guide.pdf
- How to install firmware: Text

  http://hsmm-mesh.org/documentation/68-firmware-installation-instructions.html
- How to install firmware (photos):

  http://hsmm-mesh.org/images/stories/hsmmmesh-step-by-step.pdf
- Local CC-HSMM-Mesh Yahoo! group
- DAWG-HSMM Yahoo! group

HSMM-Mesh: Key takeaways

- High speed, low cost, amateur radio network
- For EmComm, Contesting, Experimenting
- Inexpensive
- You can do it

- Questions?

- Scott Scheirman AD7XV ad7xv@arrl.net

Backup

Scott ad7xv@arrl.net

Questions?

Scott ad7xv@arrl.net

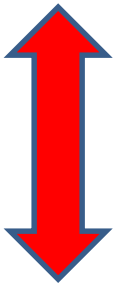
HSMM

Not just *any* WRT54G router!

Upgradable to HSMM

Model	Serial number prefix
WRT54G	CDF0 to CDFA
WRT54GS	CGN0 to CGN6
WRT54GL	CL7A to CF7A

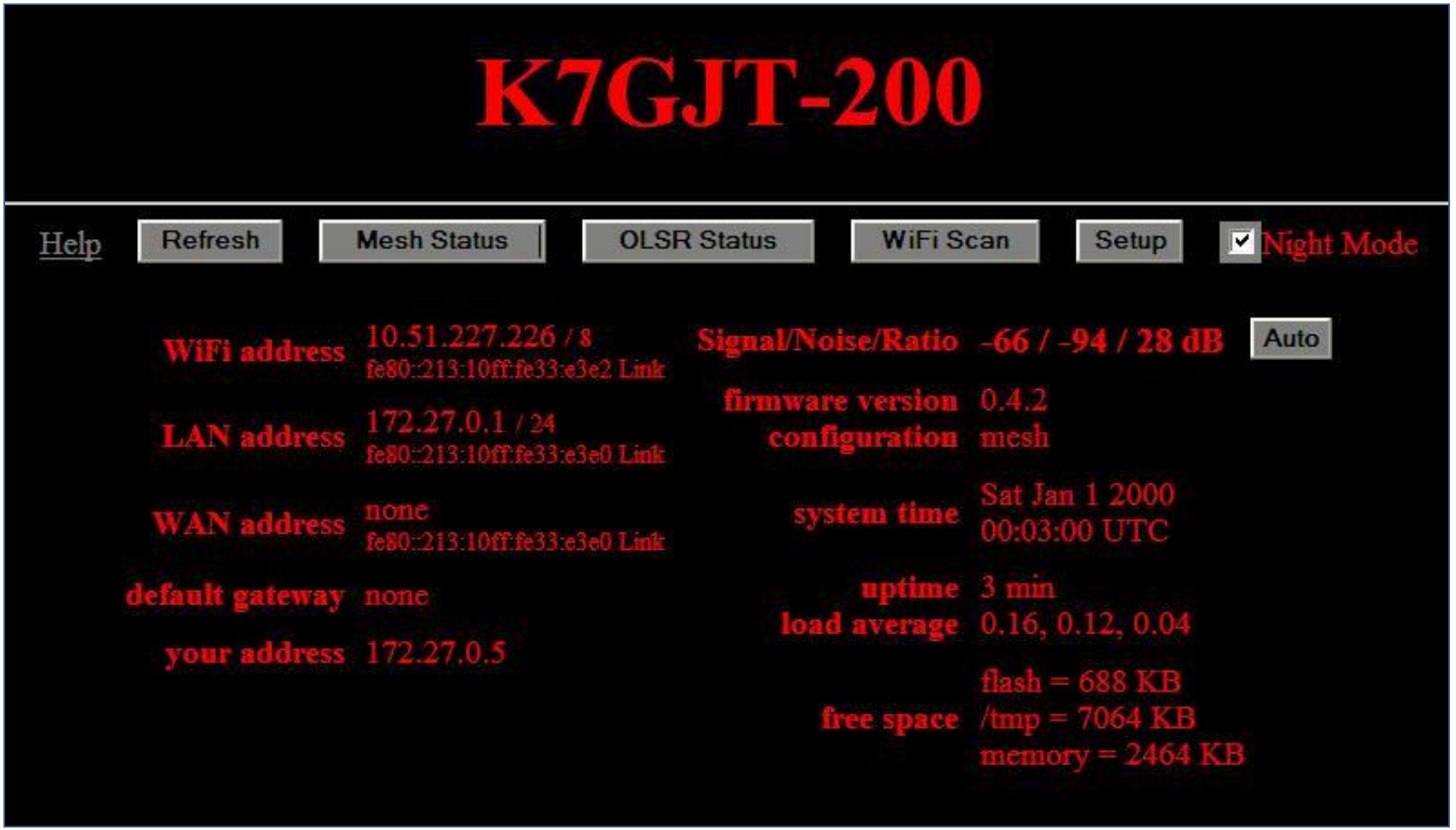
Not upgradable to HSMM



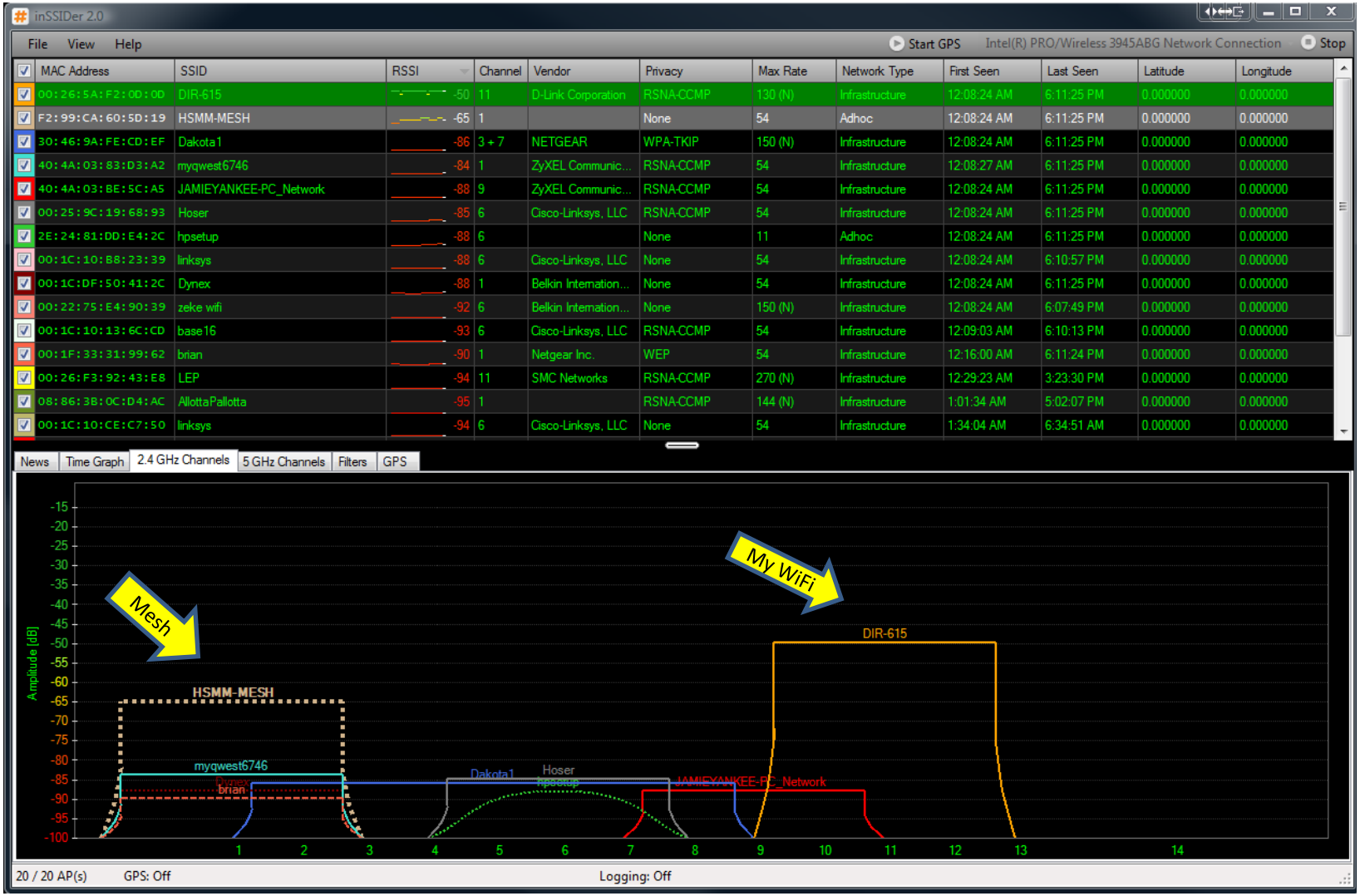
WRT54G	CDFB to CDFG, CDFJ, CDFK, MDF0
WRT54GS	CGN7 to CGNC, CGNE

Complete list is here:
http://hsmm-mesh.org/images/hsmm_docs/wrt54xx%20shopping%20guide.pdf

The ‘Night Mode’ Display



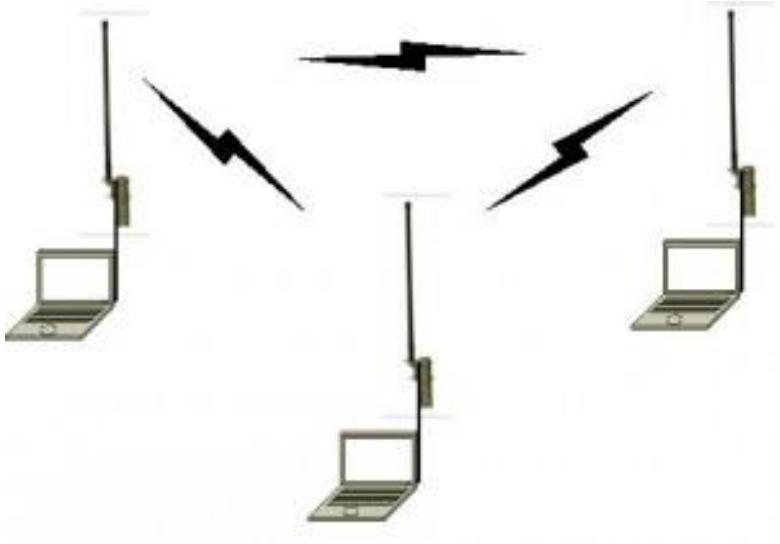
After moving my WiFi to CH 11



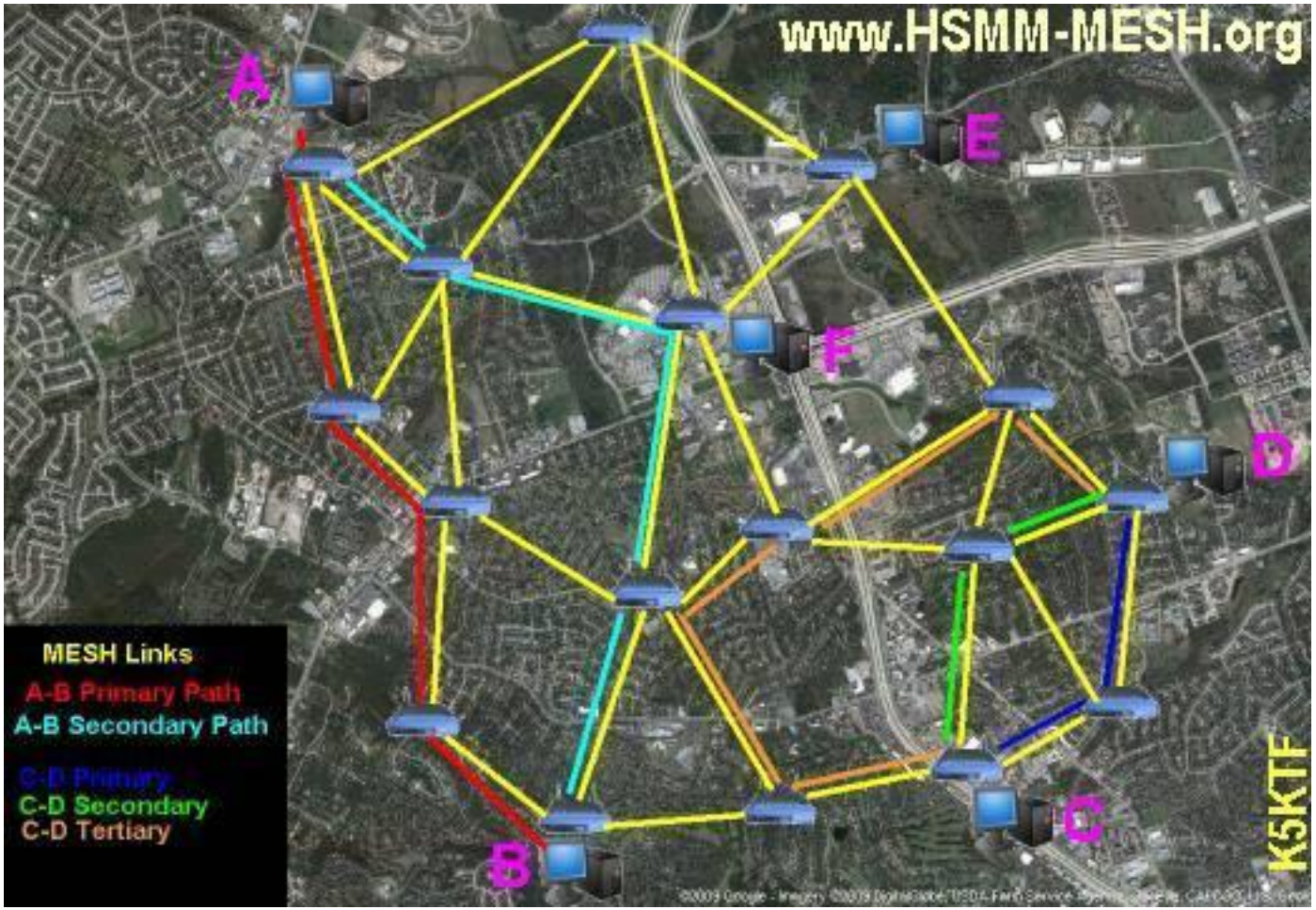
High Speed Multi Media Topologies

- Point to Point

- MESH

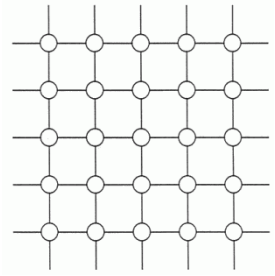


The Topology



How far will it go?

- Stock antennas? Wi-Fi design is 100 meters max
- With a node and 24dBi dish on each end:
  - 6 miles across South Austin, TX, between 2 parking garages - 100% Link Quality.
- Secondary test: 1 dish + 1/2w Bi-directional Amp, and stock 3.5dBi rubber duckies on other end !
- With a dish and a small yagi: 10 miles from central Austin to South Austin
- Walls, trees, hills, and structures present challenges!

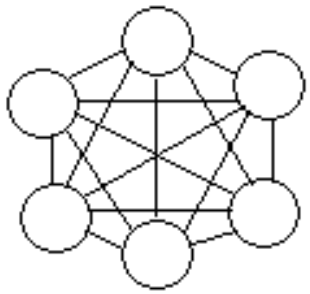


What is HSMM-Mesh?

MESH... *Noun.* The topology of a network whose components are all connected directly to every other component.

How do we do it?

Why would we want to?



Topology Entries

Destination IP		Last Hop IP		Linkcost
10.17.119.13	(KB7RHI-100)	10.203.235.5	(KJ7RD-101)	(0.831/0.525) 2.288
10.128.34.26	(AD7XV-400)	10.203.235.5	(KJ7RD-101)	(0.847/0.682) 1.729
10.103.146.50	(KD7RYY-100-100)	10.203.235.5	(KJ7RD-101)	(0.776/0.831) 1.549
10.12.237.101	(wa7ptm-CN85rq-1)	10.203.235.5	(KJ7RD-101)	(0.732/0.940) 1.448
10.172.112.115	(KJ7RD-100)	10.203.235.5	(KJ7RD-101)	(0.886/0.662) 1.702
10.205.127.125	(KE7IED-20)	10.203.235.5	(KJ7RD-101)	(0.940/0.662) 1.603
10.184.210.181	(AD7XV-200)	10.203.235.5	(KJ7RD-101)	(0.847/0.584) 2.020
10.103.166.198	(AD7XV-100)	10.203.235.5	(KJ7RD-101)	(0.847/0.627) 1.881
10.41.94.203	(kc7q00-1)	10.203.235.5	(KJ7RD-101)	(0.886/0.732) 1.538
10.14.80.206	(wa7ptm-CN85rq-2)	10.203.235.5	(KJ7RD-101)	(1.000/1.000) 1.000
10.51.227.226	(K7GJT-200)	10.203.235.5	(KJ7RD-101)	(0.874/0.466) 2.450
10.44.242.254	(K7GJT-100)	10.203.235.5	(KJ7RD-101)	(0.808/0.627) 1.973
10.203.235.5	(KJ7RD-101)	10.17.119.13	(KB7RHI-100)	(0.525/0.796) 2.390
10.128.34.26	(AD7XV-400)	10.17.119.13	(KB7RHI-100)	(0.847/0.662) 1.781
10.103.146.50	(KD7RYY-100-100)	10.17.119.13	(KB7RHI-100)	(0.474/0.776) 2.714
10.29.63.73	(AC7ZF-100)	10.17.119.13	(KB7RHI-100)	(0.662/0.776) 1.942
10.12.237.101	(wa7ptm-CN85rq-1)	10.17.119.13	(KB7RHI-100)	(0.521/0.776) 2.469
10.172.112.115	(KJ7RD-100)	10.17.119.13	(KB7RHI-100)	(0.776/0.839) 1.534
10.184.210.181	(AD7XV-200)	10.17.119.13	(KB7RHI-100)	(0.894/0.627) 1.782
10.103.166.198	(AD7XV-100)	10.17.119.13	(KB7RHI-100)	(0.897/0.940) 1.183
10.51.227.226	(K7GJT-200)	10.17.119.13	(KB7RHI-100)	(1.000/0.937) 1.066
10.44.242.254	(K7GJT-100)	10.17.119.13	(KB7RHI-100)	(0.905/1.000) 1.104
10.203.235.5	(KJ7RD-101)	10.128.34.26	(AD7XV-400)	(0.701/0.847) 1.682
10.17.119.13	(KB7RHI-100)	10.128.34.26	(AD7XV-400)	(0.732/0.847) 1.609
10.103.146.50	(KD7RYY-100-100)	10.128.34.26	(AD7XV-400)	(0.886/0.897) 1.256
10.29.63.73	(AC7ZF-100)	10.128.34.26	(AD7XV-400)	(0.937/0.897) 1.188
10.12.237.101	(wa7ptm-CN85rq-1)	10.128.34.26	(AD7XV-400)	(0.682/0.839) 1.746
10.172.112.115	(KJ7RD-100)	10.128.34.26	(AD7XV-400)	(0.831/0.748) 1.605
10.205.127.125	(KE7IED-20)	10.128.34.26	(AD7XV-400)	(0.831/0.897) 1.339
10.184.210.181	(AD7XV-200)	10.128.34.26	(AD7XV-400)	(0.901/0.697) 1.588
10.103.166.198	(AD7XV-100)	10.128.34.26	(AD7XV-400)	(0.944/0.948) 1.114
10.41.94.203	(kc7q00-1)	10.128.34.26	(AD7XV-400)	(0.886/0.748) 1.506
10.51.227.226	(K7GJT-200)	10.128.34.26	(AD7XV-400)	(0.937/0.521) 2.045
10.44.242.254	(K7GJT-100)	10.128.34.26	(AD7XV-400)	(0.808/0.788) 1.570
10.203.235.5	(KJ7RD-101)	10.103.146.50	(KD7RYY-100-100)	(0.831/0.776) 1.549
10.17.119.13	(KB7RHI-100)	10.103.146.50	(KD7RYY-100-100)	(0.788/0.474) 2.673
10.128.34.26	(AD7XV-400)	10.103.146.50	(KD7RYY-100-100)	(0.886/0.886) 1.272
10.29.63.73	(AC7ZF-100)	10.103.146.50	(KD7RYY-100-100)	(1.000/0.937) 1.066
10.12.237.101	(wa7ptm-CN85rq-1)	10.103.146.50	(KD7RYY-100-100)	(0.682/0.831) 1.763
10.172.112.115	(KJ7RD-100)	10.103.146.50	(KD7RYY-100-100)	(0.886/0.607) 1.855
10.205.127.125	(KE7IED-20)	10.103.146.50	(KD7RYY-100-100)	(0.831/1.000) 1.202
10.184.210.181	(AD7XV-200)	10.103.146.50	(KD7RYY-100-100)	(0.847/0.442) 2.664

olsr.org OLSR daemon on K7GJT-100

Configuration | Routes | Links/Topology | All | About | Node Status

Links

Local IP		Remote IP		Hysteresis	LinkCost
10.44.242.254	(K7GJT-100)	10.51.227.226	(K7GJT-200)	0.00	(1.000/0.948) 1.054
10.44.242.254	(K7GJT-100)	10.184.210.181	(AD7XV-200)	0.00	(0.897/0.713) 1.560
10.44.242.254	(K7GJT-100)	10.17.119.13	(KB7RHI-100)	0.00	(0.886/0.948) 1.188
10.44.242.254	(K7GJT-100)	10.205.127.125	(KE7IED-20)	0.00	(0.682/0.000) INFINITE
10.44.242.254	(K7GJT-100)	10.41.94.203	(kc7q00-1)	0.00	(0.831/0.901) 1.333
10.44.242.254	(K7GJT-100)	10.203.235.5	(KJ7RD-101)	0.00	(0.662/0.796) 1.895
10.44.242.254	(K7GJT-100)	10.29.63.73	(AC7ZF-100)	0.00	(0.662/0.725) 2.079
10.44.242.254	(K7GJT-100)	10.103.166.198	(AD7XV-100)	0.00	(0.643/0.847) 1.835
10.44.242.254	(K7GJT-100)	10.103.146.50	(KD7RYY-100-100)	0.00	(0.682/0.761) 1.926
10.44.242.254	(K7GJT-100)	10.172.112.115	(KJ7RD-100)	0.00	(0.886/1.000) 1.128
10.44.242.254	(K7GJT-100)	10.128.34.26	(AD7XV-400)	0.00	(0.776/0.847) 1.520
10.44.242.254	(K7GJT-100)	10.12.237.101	(wa7ptm-CN85rq-1)	0.00	(0.576/0.796) 2.179
10.44.242.254	(K7GJT-100)	10.14.80.206	(wa7ptm-CN85rq-2)	0.00	(0.427/0.000) INFINITE

Neighbors

IP Address		SYM	MPR	MPRS	Willingness	2 Hop Neighbors
10.205.127.125	(KE7IED-20)	NO	NO	NO	3	IP ADDRESS (11)
10.51.227.226	(K7GJT-200)	YES	YES	NO	3	IP ADDRESS (12)
10.12.237.101	(wa7ptm-CN85rq-1)	YES	YES	YES	3	IP ADDRESS (13)
10.41.94.203	(kc7q00-1)	YES	YES	YES	3	IP ADDRESS (11)
10.103.166.198	(AD7XV-100)	YES	YES	YES	3	IP ADDRESS (10)
10.128.34.26	(AD7XV-400)	YES	YES	YES	3	IP ADDRESS (12)
10.14.80.206	(wa7ptm-CN85rq-2)	NO	NO	NO	3	IP ADDRESS (9)
10.203.235.5	(KJ7RD-101)	YES	YES	YES	3	IP ADDRESS (12)
10.103.146.50	(KD7RYY-100-100)	YES	YES	YES	3	IP ADDRESS (12)
10.17.119.13	(KB7RHI-100)	YES	YES	YES	3	IP ADDRESS (10)
10.29.63.73	(AC7ZF-100)	YES	YES	YES	3	IP ADDRESS (11)
10.172.112.115	(KJ7RD-100)	YES	YES	YES	3	IP ADDRESS (12)
10.184.210.181	(AD7XV-200)	YES	YES	YES	3	IP ADDRESS (12)

How does it work?

- An HSMM-MESH node provides an endpoint connection AND a repeater
- Self-configuring
  - Handles node drop out (routes around it)
  - Automatically ‘routes’

K7GJT & KB7RHI path testing