



P25NX – Worldwide P25 Repeater Linking

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WHO WILL SURVIVE?

What is P25

- ▶ APCO Project 25
- ▶ Primary use is public safety
- ▶ Motorola Quantar is most used amateur repeater



Quantar Interface

- ▶ Internal TTL level interface on wireline card
- ▶ Motorola V.24 interface daughtercard
- ▶ V.24 specifies physical interface only – not the protocol
- ▶ First layer protocol is bit-based HDLC

Linking options before P25NX

- ▶ Point-to-point via modems or microwave
- ▶ Limited multipoint with AstroTac comparator



Anatomy of the V24 Data

HEADER

```
00 02 04 0c 0b 00 00 00 00 00
60 02 04 0c 0b 1b 5a 1a 2e 00 00 00 00 00 00 00 00 00 00 00 00 00 08 00 00 00 00 00 3a
61 00 01 17 14 2a 10 33 31 00 39 2a 22 04 23 12 11 0a 00 03 0c 02
```

LDU1

```
62 02 04 0c 0b 1b 5b 1a 2d 80 04 0c fd 7b fb 7d f2 7b 3d 9e 44 02
63 04 0c fd 7b fb 7d f2 7b 3d 9e 45 00 7a
64 00 00 00 00 04 0c fd 7b fb 7d f2 7b 3d 9e 44 02
65 00 00 01 00 04 0c fd 7b fb 7d f2 7b 3d 9e 45 02
66 5a 5a 5a 00 04 0c fd 7b fb 7d f2 7b 3d 9e 44 02
67 b5 75 2d 00 04 0c fd 7b fb 7d f2 7b 3d 9e 45 02
68 45 62 ec 00 04 0c fd 7b fb 7d f2 7b 3d 9e 44 02
69 5d 1e d4 00 04 0c fd 7b fb 7d f2 7b 3d 9e 45 02
6a 82 88 06 04 0c fd 7b fb 7d f2 7b 3d 9e 44 00
```

IMBE VOICE DATA
IN RED

LDU2

```
6b 02 04 0c 0b 1b 5a 1a 2e bc 04 0c fd 7b fb 7d f2 7b 3d 9e 45 02
6c 04 0c fd 7b fb 7d f2 7b 3d 9e 44 00 7a
6d 00 00 00 00 04 0c fd 7b fb 7d f2 7b 3d 9e 45 02
6e 00 00 00 00 04 0c fd 7b fb 7d f2 7b 3d 9e 44 02
6f 00 00 00 00 04 0c fd 7b fb 7d f2 7b 3d 9e 45 02
70 80 00 00 00 04 0c fd 7b fb 7d f2 7b 3d 9e 44 02
71 ac b8 a4 00 04 0c fd 7b fb 7d f2 7b 3d 9e 45 02
72 9b dc 75 00 04 0c fd 7b fb 7d f2 7b 3d 9e 44 02
73 f1 70 06 04 0c fd 7b fb 7d f2 7b 3d 9e 45 00
```

TERMINATOR

```
00 02 04 25 0b 00 00 00 00 00
00 02 04 25 0b 00 00 00 00 00
```

Problem: Turn HDLC Sync to IP

- ▶ HDLC old protocol. Not widely supported anymore
- ▶ Sync to Async converters available, but expensive
- ▶ After conversion, still need to get to IP

Solution: Surplus Cisco Routers



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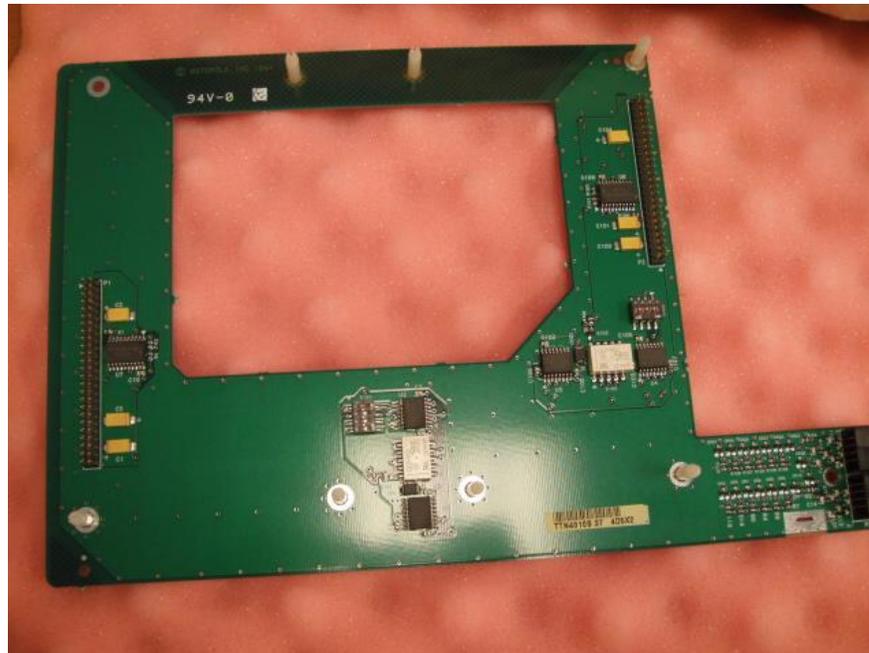
- ▶ Modular
- ▶ Supports HDLC conversion
- ▶ Supports serial tunneling over IP
- ▶ Inexpensive and readily available

Solution: Surplus Cisco Routers



WIC-1T Interface & Cable

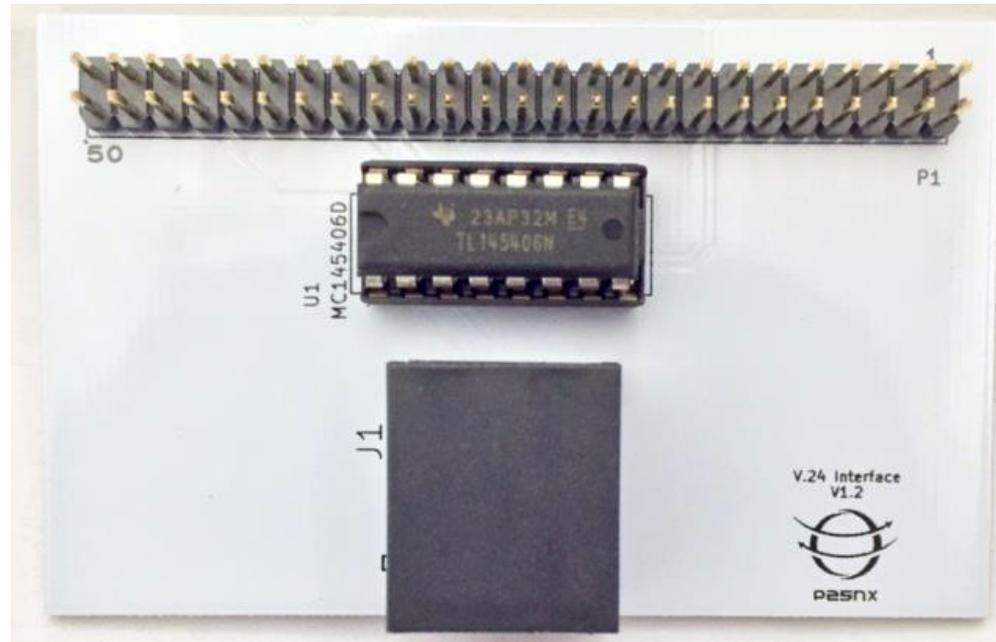
Quantar Interface



Quantar Interface



Quantar Interface



P25NX Interface Board

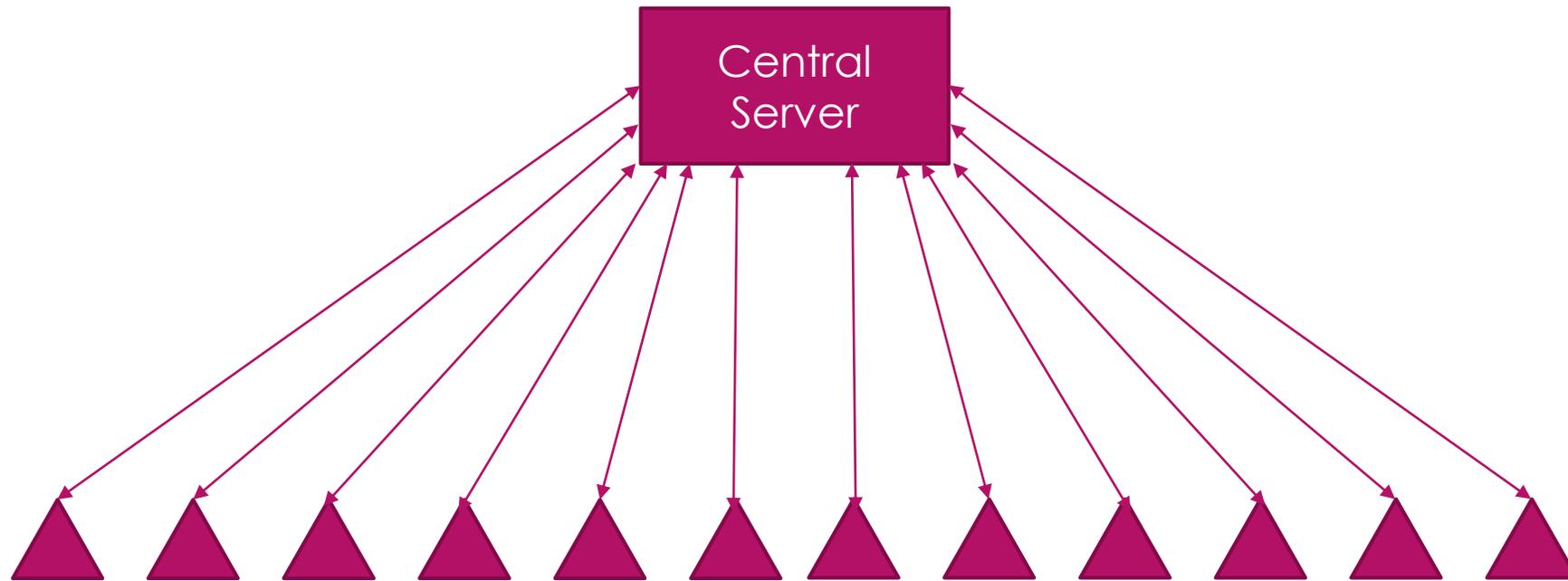
Software Time



Version 1 – “Quantar Site Connect”

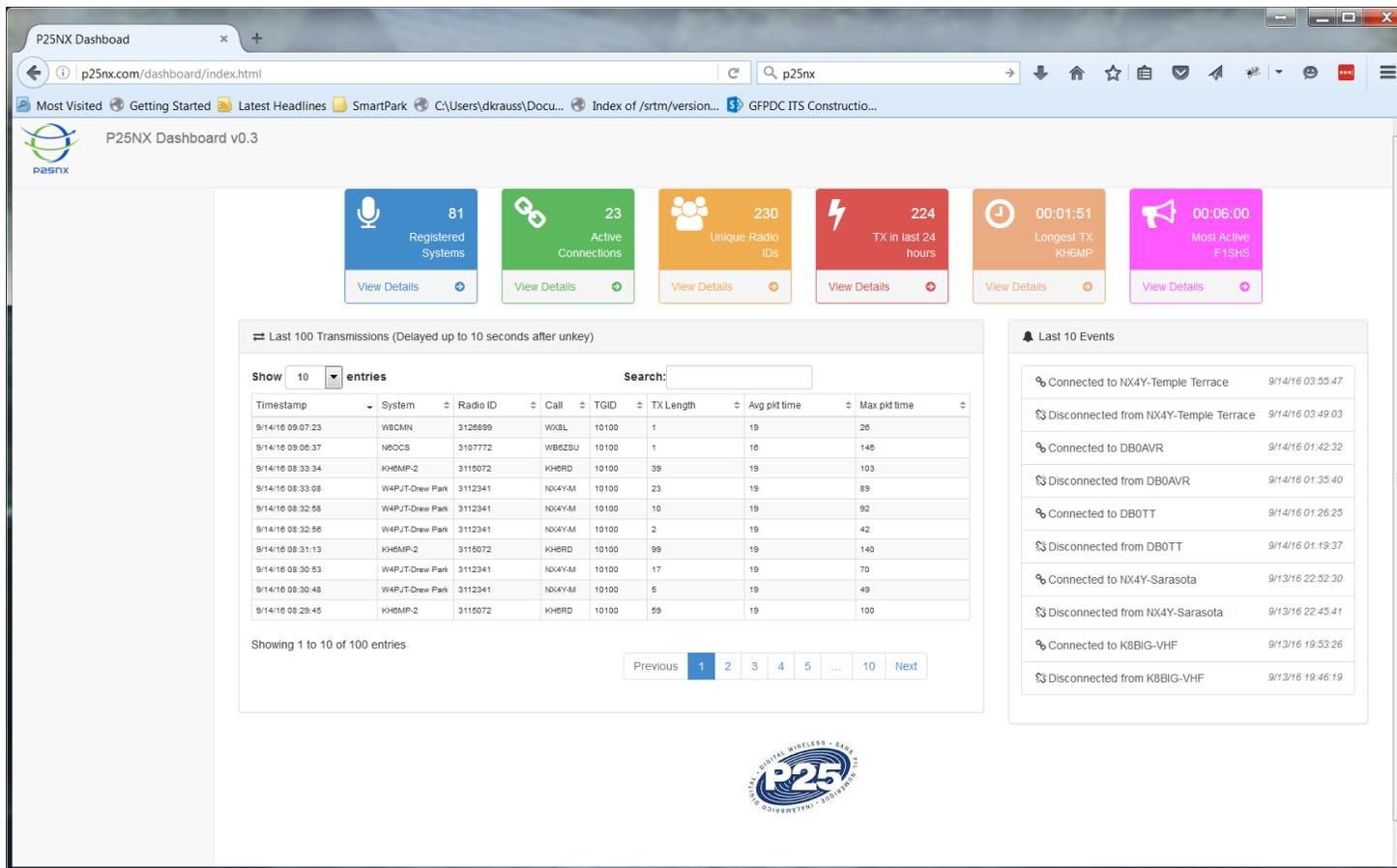
- ▶ Central Server acts as TCP Reflector
- ▶ Custom code in C#
- ▶ Closed Source
- ▶ Supports one worldwide talkgroup

Version 1 – “Quantar Site Connect”



Repeaters

Web Dashboard



The screenshot shows the P25NX Dashboard v0.3 web interface. At the top, there are six summary cards with icons and data:

- 81 Registered Systems (blue card)
- 23 Active Connections (green card)
- 230 Unique Radio IDs (orange card)
- 224 TX in last 24 hours (red card)
- 00:01:51 Longest TX KH6MP (light orange card)
- 00:06:00 Most Active F1SHS (purple card)

Below these cards are two main sections:

Last 100 Transmissions (Delayed up to 10 seconds after unkey)

Search:

Timestamp	System	Radio ID	Call	TGID	TX Length	Avg pkt time	Max pkt time
9/14/16 09:07:23	WBCMN	3128899	WXBL	10100	1	19	26
9/14/16 09:08:37	NBOCS	3107772	WBZSU	10100	1	16	146
9/14/16 08:33:34	KH6MP-2	3115072	KH6RD	10100	39	19	103
9/14/16 08:33:08	W4PJT-Drew Park	3112341	NX4Y-M	10100	23	19	89
9/14/16 08:32:58	W4PJT-Drew Park	3112341	NX4Y-M	10100	10	19	92
9/14/16 08:32:56	W4PJT-Drew Park	3112341	NX4Y-M	10100	2	19	42
9/14/16 08:31:13	KH6MP-2	3115072	KH6RD	10100	99	19	140
9/14/16 08:30:53	W4PJT-Drew Park	3112341	NX4Y-M	10100	17	19	70
9/14/16 08:30:48	W4PJT-Drew Park	3112341	NX4Y-M	10100	5	19	49
9/14/16 08:29:45	KH6MP-2	3115072	KH6RD	10100	59	19	100

Showing 1 to 10 of 100 entries

Navigation: Previous | 1 | 2 | 3 | 4 | 5 | ... | 10 | Next

Last 10 Events

- Connected to NX4Y-Temple Terrace 9/14/16 03:55:47
- Disconnected from NX4Y-Temple Terrace 9/14/16 03:49:03
- Connected to DB0AVR 9/14/16 01:42:32
- Disconnected from DB0AVR 9/14/16 01:35:40
- Connected to DB0TT 9/14/16 01:26:25
- Disconnected from DB0TT 9/14/16 01:19:37
- Connected to NX4Y-Sarasota 9/13/16 22:52:30
- Disconnected from NX4Y-Sarasota 9/13/16 22:45:41
- Connected to K8BIG-VHF 9/13/16 19:53:26
- Disconnected from K8BIG-VHF 9/13/16 19:46:19



Last 100 Transmissions

⇌ Last 100 Transmissions (Delayed up to 10 seconds after unkey)

Show entries

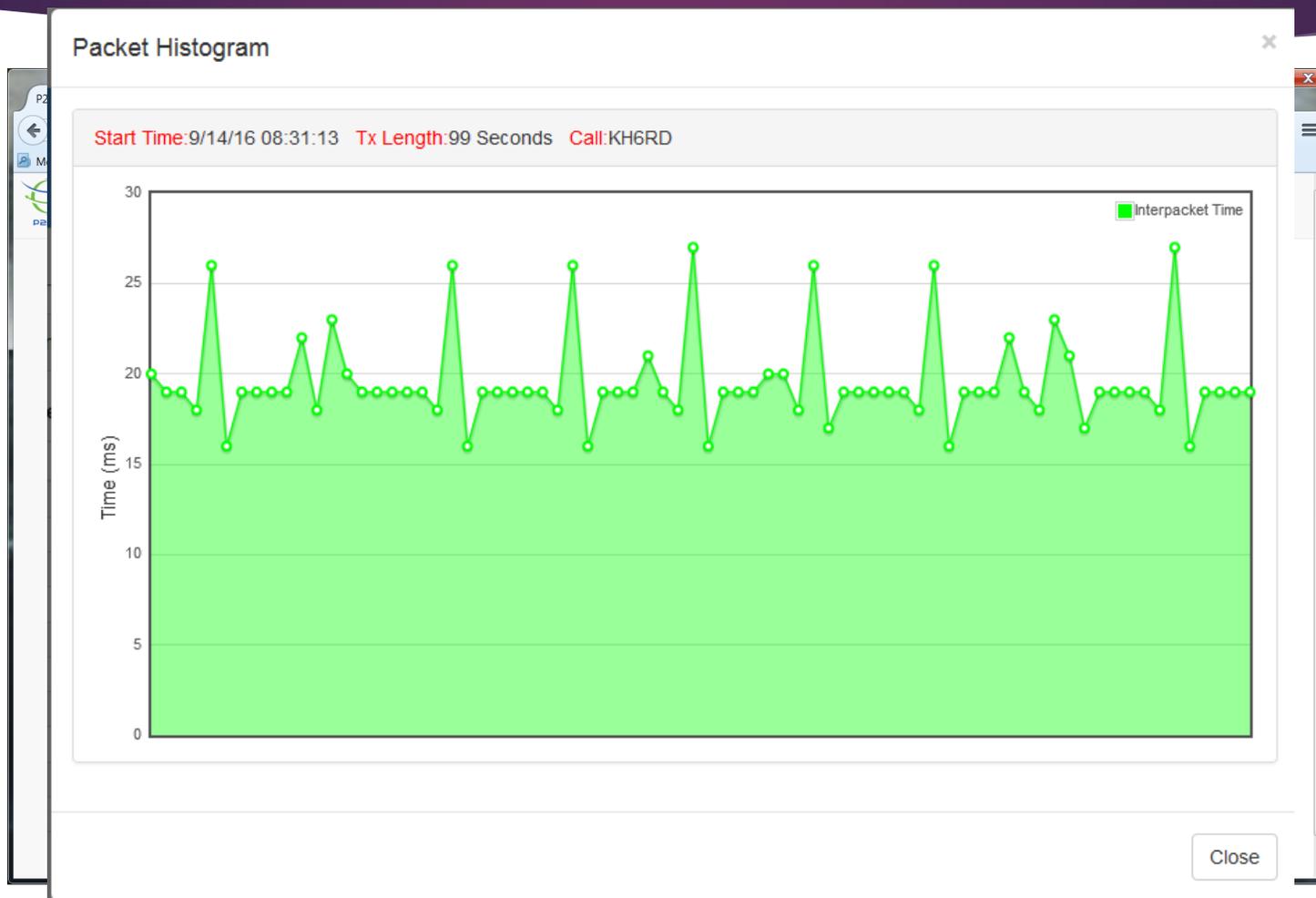
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Showing 1 to 10 of 100 entries

[Previous](#)
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[Next](#)

Last 100 Transmissions



V1 Limitations

- ▶ Single point of failure
- ▶ Audio quality not consistent
- ▶ Limited to one talkgroup without major recoding
- ▶ Wanted to move to distributed model
- ▶ Required hefty Windows server with MS SQL Database

Version 2 – P25 Network Exchange

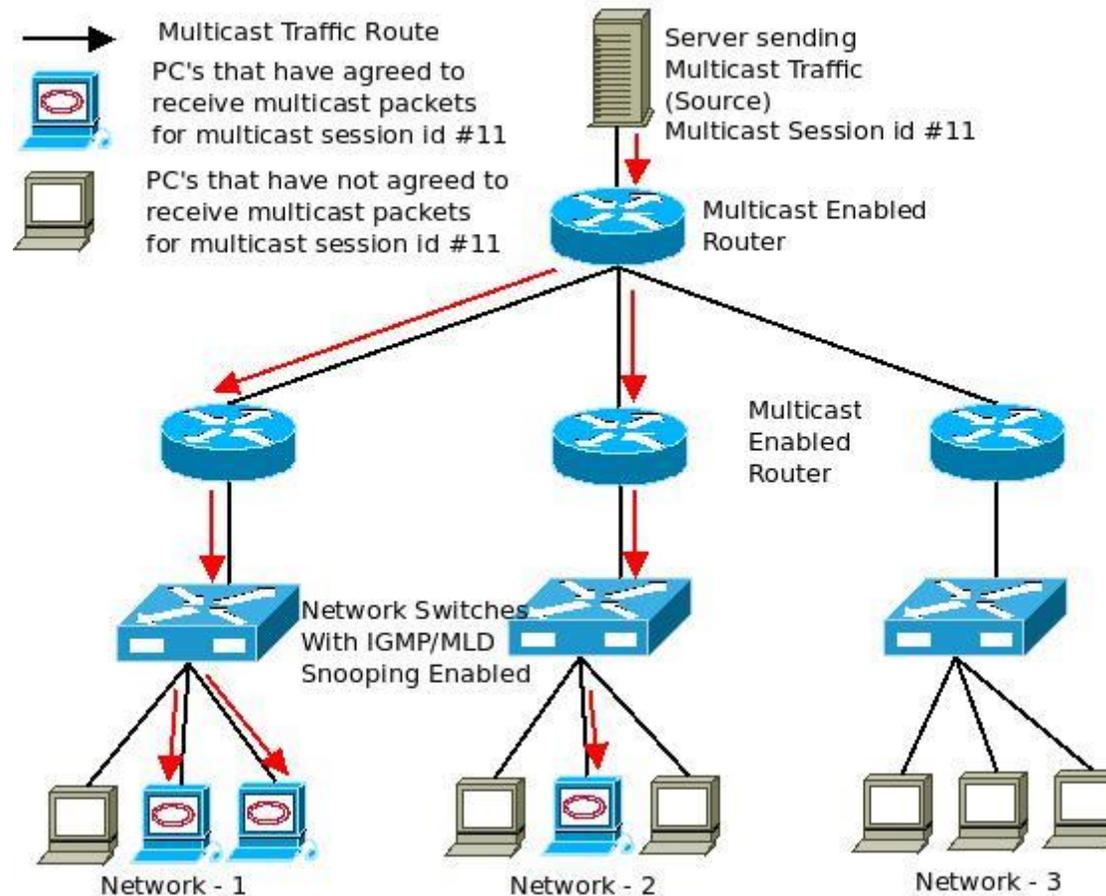
- ▶ Distributed model
- ▶ High quality audio
- ▶ Nearly unlimited on-demand talkgroups
- ▶ Lets “the network be the network”
- ▶ Platform independence

IP Multicast

- ▶ One to many system
- ▶ Reduces system bandwidth
- ▶ Talkgroups can be multicast groups
- ▶ Not generally supported over the Internet

IP Multicast

Guide



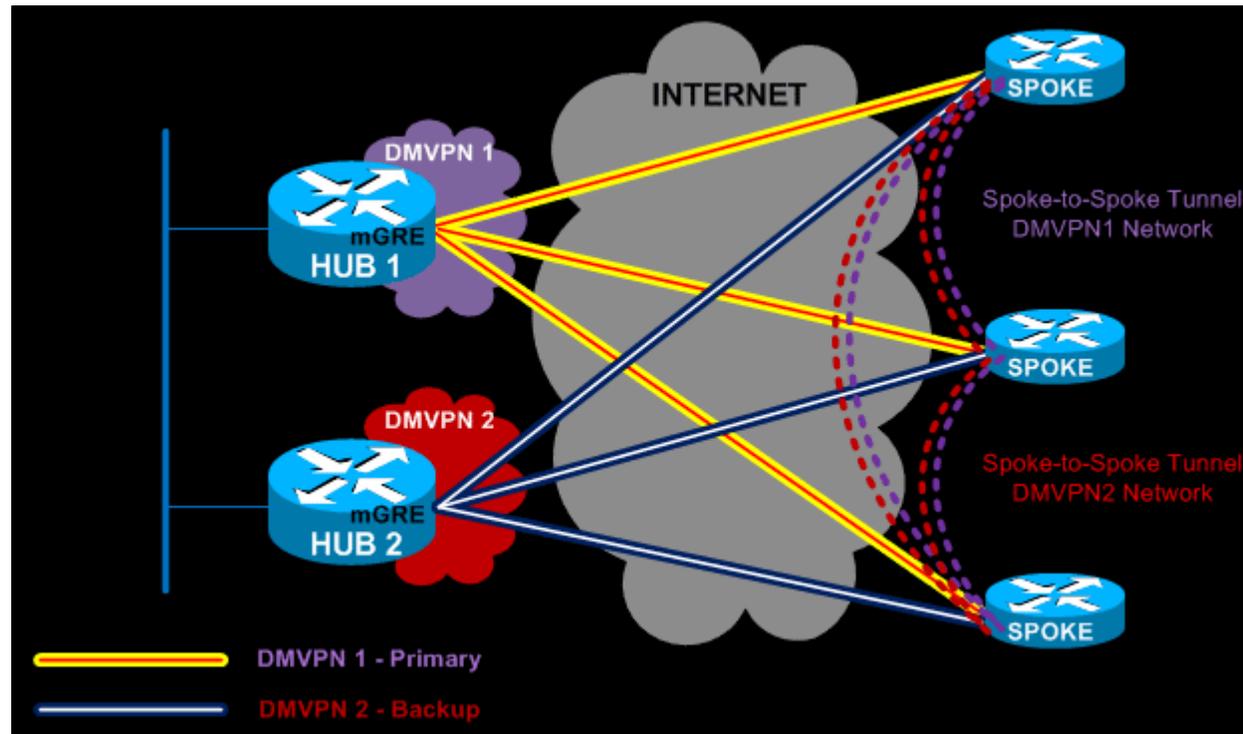
IP Multicast over the Internet

- ▶ I said it wouldn't work. Oops.
- ▶ Dynamic Multipoint
Virtual Private Network

DMVPN

- ▶ What the heck is DMVPN?
- ▶ Series of TCP/IP Tunnels between unknown and known endpoints
- ▶ Hubs must have real, static IP addresses
- ▶ Spokes can be behind firewalls, DHCP, Mobile...

IP Multicast over DMVPN



ARE YOU AFRAID YET??

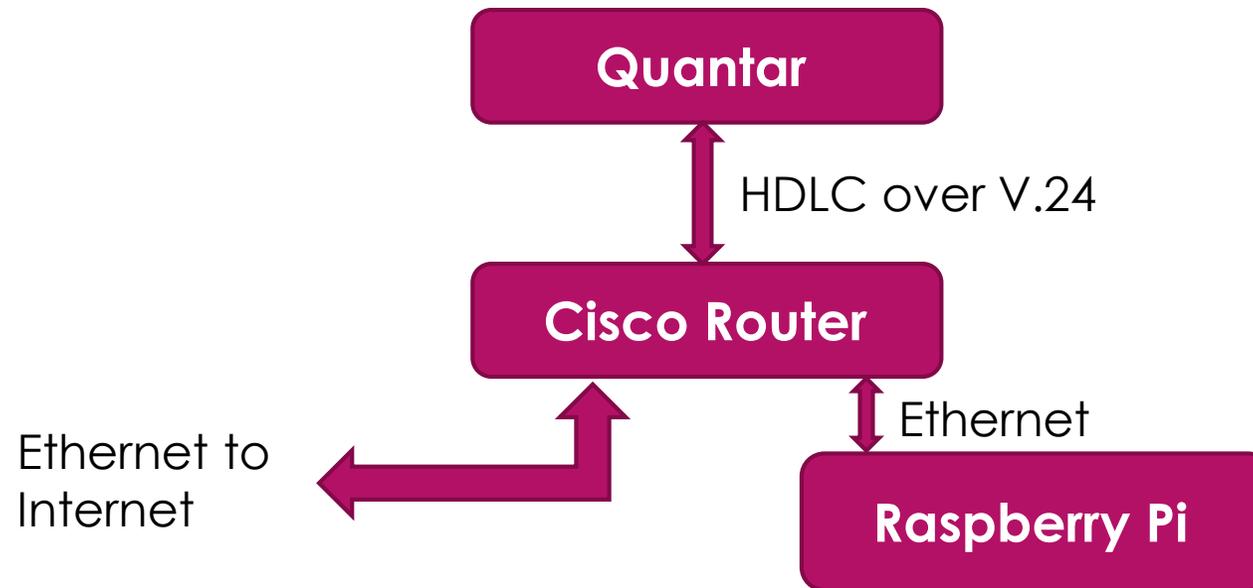


Version 2 Software

Or, I had to recode it anyway.

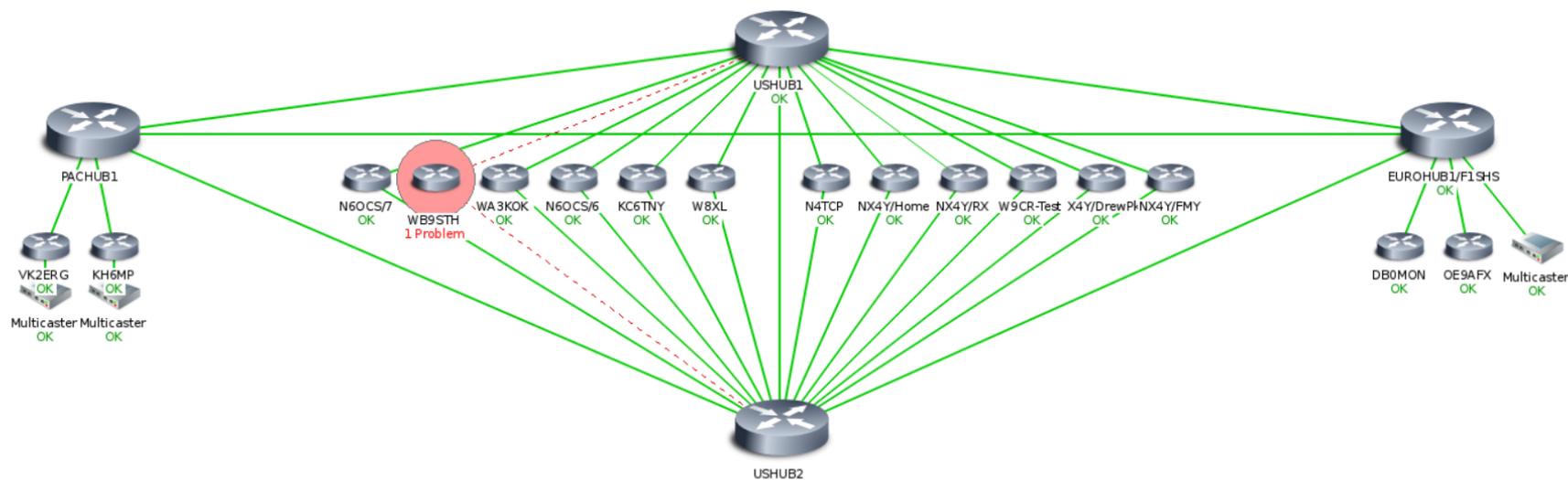
- ▶ Version 2 code in C# under “Mono”
- ▶ Mono allows native .NET framework to run under Linux
- ▶ V2 using Raspberry Pi or Beaglebone Black

Repeater Site Configuration



Network Management System

Network Status



Worldwide Connections

- ▶ Texas
- ▶ New York
- ▶ N. Carolina
- ▶ Detroit
- ▶ Chicago
- ▶ Sacramento
- ▶ Florida
- ▶ Hawaii
- ▶ Las Vegas
- ▶ SoCal
- ▶ NoCal
- ▶ Wisconsin
- ▶ New Zealand
- ▶ Australia
- ▶ Germany
- ▶ France
- ▶ Austria
- ▶ England soon

Next Steps?

- ▶ Working with MMDVM Group for non-Quantars
- ▶ Add more redundancy (hubs)
- ▶ Add features
- ▶ Enhance Website
- ▶ Mobile app for repeater monitoring

You Made it !



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NX4Y After 12 hours of coding...