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 08 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 8b 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 00 04 0c fd 7b fb 7d f2 7b 3d 9e 44 02
65 00 00 01 00 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**

```
6b 02 04 0c 0b 1b 5a 1a 2e b0 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 00 04 0c fd 7b fb 7d f2 7b 3d 9e 45 02
6e 00 00 00 00 00 04 0c fd 7b fb 7d f2 7b 3d 9e 44 02
6f 00 00 00 00 00 04 0c fd 7b fb 7d f2 7b 3d 9e 45 02
70 80 00 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
```

**LDU2**

```
```

**TERMINATOR**

```
00 02 04 0c 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
Solution: Surplus Cisco Routers

- 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

I CAN’T FIND ONE!
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”

Central Server

Repeaters
Web Dashboard
<table>
<thead>
<tr>
<th>Time Stamp</th>
<th>System</th>
<th>Radio ID</th>
<th>Call</th>
<th>TQID</th>
<th>TX Length</th>
<th>Avg pkt time</th>
<th>Max pkt time</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/14/16 09:07:23</td>
<td>WSCMN</td>
<td>3125589</td>
<td>VXXL</td>
<td>10100</td>
<td>1</td>
<td>19</td>
<td>20</td>
</tr>
<tr>
<td>9/14/16 09:06:37</td>
<td>N60CS</td>
<td>2107772</td>
<td>W66ZSU</td>
<td>10100</td>
<td>1</td>
<td>16</td>
<td>146</td>
</tr>
<tr>
<td>9/14/16 08:33:34</td>
<td>KHEM-P-2</td>
<td>3115072</td>
<td>KHEMRO</td>
<td>10100</td>
<td>39</td>
<td>19</td>
<td>103</td>
</tr>
<tr>
<td>9/14/16 08:33:08</td>
<td>W4PJT-Crew Park</td>
<td>3112341</td>
<td>NX4Y-M</td>
<td>10100</td>
<td>23</td>
<td>19</td>
<td>99</td>
</tr>
<tr>
<td>9/14/16 08:32:58</td>
<td>W4PJT-Crew Park</td>
<td>3112341</td>
<td>NX4YM</td>
<td>10100</td>
<td>10</td>
<td>19</td>
<td>92</td>
</tr>
<tr>
<td>9/14/16 08:32:50</td>
<td>W4PJT-Crew Park</td>
<td>3112341</td>
<td>NX4YM</td>
<td>10100</td>
<td>2</td>
<td>19</td>
<td>42</td>
</tr>
<tr>
<td>9/14/16 08:31:13</td>
<td>KHEM-P-2</td>
<td>3115072</td>
<td>KHEMRO</td>
<td>10100</td>
<td>99</td>
<td>19</td>
<td>140</td>
</tr>
<tr>
<td>9/14/16 08:30:53</td>
<td>W4PJT-Crew Park</td>
<td>3112341</td>
<td>NX4YM</td>
<td>10100</td>
<td>17</td>
<td>19</td>
<td>70</td>
</tr>
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<td>9/14/16 08:30:48</td>
<td>W4PJT-Crew Park</td>
<td>3112241</td>
<td>NX4YM</td>
<td>10100</td>
<td>5</td>
<td>19</td>
<td>49</td>
</tr>
<tr>
<td>9/14/16 08:29:48</td>
<td>KHEM-P-2</td>
<td>3115072</td>
<td>KHEMRO</td>
<td>10100</td>
<td>59</td>
<td>19</td>
<td>100</td>
</tr>
</tbody>
</table>

Showing 1 to 10 of 100 entries
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

- Multicast Traffic Route
- PCs that have agreed to receive multicast packets for multicast session id #11
- PCs that have not agreed to receive multicast packets for multicast session id #11
- Server sending Multicast Traffic (Source)
- Multicast Session ID #11
- Multicast Enabled Router
- Network Switches with IGMP/MLD Snooping Enabled
- Network - 1
- Network - 2
- Network - 3
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

Quantar

HDLC over V.24

Cisco Router

Ethernet to Internet

Ethernet

Raspberry Pi
Network Management System
Worldwide Connections

- Texas
- New York
- N. Carolina
- Detroit
- Chicago
- Sacramento
- Florida
- Hawaii
- Las Vegas
- SoCal
- NoCal
- 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...