Use of Mesh Networks To Expand Radio Communications

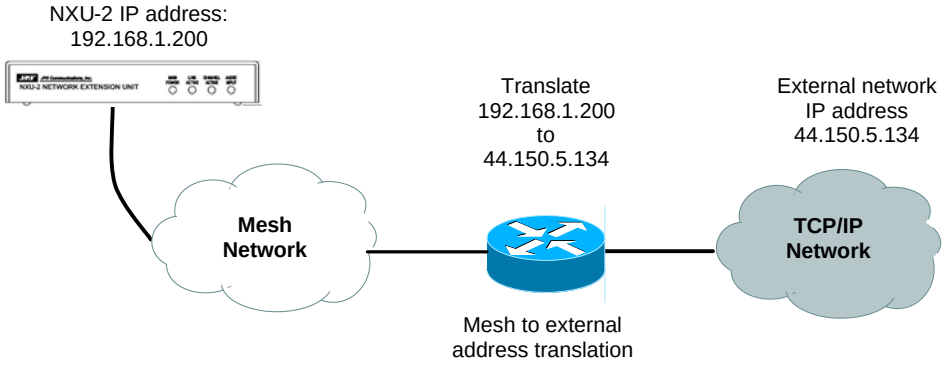
Purpose

This Application Note will describe the use of Mesh Networks with the NXU and RoIP (Radio Over Internet Protocol).

Introduction

Mesh networks are being introduced in many areas. Some Mesh networks are relatively small, perhaps covering a housing complex, while others are being deployed in larger areas, sometimes city wide. One of the largest Mesh networks is in Taiwan.

Mesh networks are typically established by utilizing existing 802.11b or 802.11g Wi-Fi technology. Each node in the network is composed by dedicated equipment such as a Mesh router, or a dedicated computer running special software. The more nodes available, the larger and more robust the network becomes.



In a traditional network, routers are used to route network traffic from one specific location to another. A Mesh network is decentralized, and does not require predetermined routing paths for the data. In a Mesh network, as each node comes online, it announces its presence to the other nodes. It informs the other nodes of its address, and routing compatibilities. Mesh networks continuously adapt to the network environment as nodes appear and disappear. The main drawback of a Mesh network is slightly longer transit time due to the lack of predetermined packet routing.

Requirement

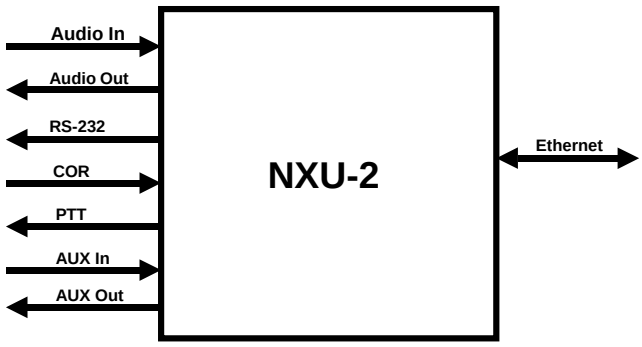
Expansion of LMR (Land Mobile Radio) communications into a poorly covered area as cost effectively as possible. Raytheon's NXU Network Extension Unit can be used to remote locate a transceiver into the area. In a situation where a traditional "wired" TCP/IP network is not available as a RoIP (Radio Over Internet Protocol) transport, a wireless Mesh network can sometimes be used.

Solutions

Raytheon's NXU Network Extension Unit is a standalone device that interfaces full-duplex audio, (1) RS-232 port and (4) status bits onto a TCP/IP Ethernet network. The NXU uses RoIP to convert LMR audio to data packets, which can then be routed over an existing digital network. The NXU can also address the essential control signals used by LMR systems. These control

Raytheon
5800 Departure Drive
Raleigh, NC 27616
919.790.1011
http://www.raytheon.com

signals consist of the COR signal generated by a device when it receives a radio transmission, and the PTT signal which requests a device to begin a radio transmission.



Two NXUs can be associated across a TCP/IP network by assigning one NXU as a *Server*, and the other NXU as a *Client*. The purpose the *Server NXU* is to wait on the network for a client NXU to connect to it. The purpose of the *Client NXU* is to locate and connect to as specific Server NXU over the network.

Advantages of the NXU Link:

Virtual dedicated line, similar to leased-line.

Full Period, “Always ON” Connectivity.

Minimal latency

Little or no reoccurring costs if utilizing agency’s existing network.

Server / Client association is dynamic. User can associate to different assets as need for diversity or redundancy.

The NXU has (3) primary connections:

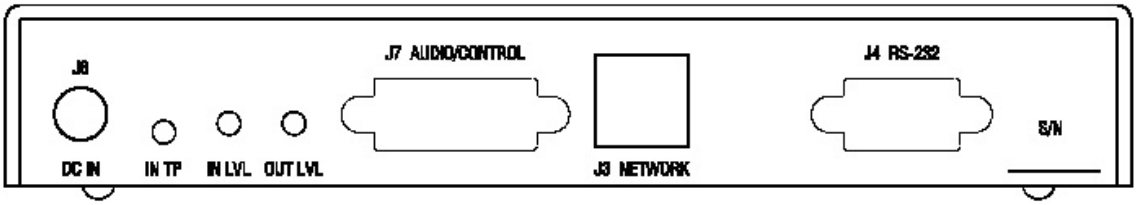
J3 – RJ45 TCP/IP Network Connection, 10 mb/s Ethernet. Able to connect back-to-back NXUs using CAT5 Cross Over cable, or over a segmented network using CAT5 Straight-Thru cables.

J4 – RS-232, Asynchronous, Full Duplex. DB-9 connection used for serial programming of the NXU, as will as means of transmitting RS-232 data from one NXU to another NXU at a maximum user selectable baud rate of 115200 bps. This auxiliary RS-232 link can be used to control serial equipment over the network

J7 – Audio / Control (2-Wire / 4-Wire Interface). DB-15 connection that will accept any Raytheon supplied or end-user built radio interface cable. All baseband audio, COR and PTT control signals from the land-mobile radio device will interface to this connection.

Raytheon
5800 Departure Drive
Raleigh, NC 27616
919.790.1011
http://www.raytheon.com

NXU Rear Panel Connectors



Any of the ACU Radio Interface Cables manufactured by Raytheon can be used to interface a radio to the NXU unit. However, the supplied crossover adapter must be inserted between the NXU J7 connector and the Raytheon Built Radio Interface Cable to “Crossover” the proper control signals. Naturally, the end-user can fabricate similar cables and connect the leads to the associated pin on connector J7, thus eliminating the need to use the Crossover Adapter.

J7 Connector Description

PIN	Signal	Description
1	Ground	Ground connection.
2		Not used.
3	/AUX In 0	Auxiliary Input 0 - Active low.
4	/AUX Out 0	Auxiliary Output 0 - Active low.
5	Ground	Ground connection.
6	Audio Input	Balanced audio input.
7	Analog Ground	Analog ground.
8	Audio Output	Unbalanced Audio output.
9		Not used.
10	/AUX In 1	Auxiliary Input 1 - Active low; general purpose.
11	/AUX Out 1	Auxiliary Output 1 - Active low; general purpose.
12	/COR Input	Input from radio COR, programmable active high or low.
13	/PTT Out	Output to radio PTT, active low, open drain.
14	Audio Input	Balanced audio input.
15	Analog Ground	Analog ground.

Although it is recommended that the input and output of the NXU be balanced, the unit can accommodate single-ended connections by grounding one of the balance lead of the NXU to the audio ground. The COR and PTT control signal connections to and from the radio device is also accommodated by the J7 connector.

Network Configuration of NXU:

It is imperative that the network be configured such that the Server and Client NXUs have network visibility between themselves, otherwise the link will not be possible.

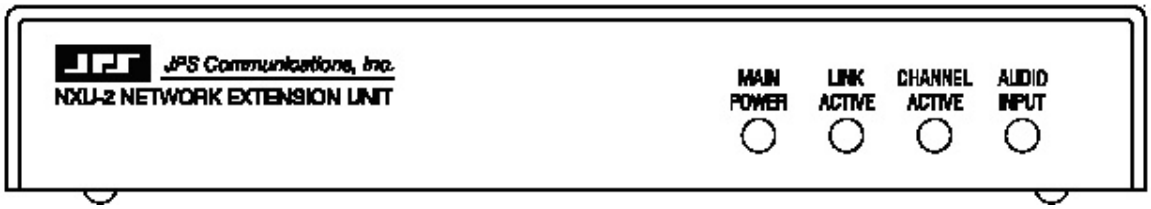
Server NXU: This NXU must have a unique static IP Address, and be configured as a SERVER.

Client NXU: This NXU must also have a unique IP Address, and be configured as a CLIENT. This address can be dynamically assigned. Additionally, this client NXU must have the “Server IP Address” field entered with the IP address of the Server NXU that it will be associating with.

If the devices are configured correctly the Link Active LED on each of the NXUs will be lit, indicating that a communications path is open between the units.

Raytheon
5800 Departure Drive
Raleigh, NC 27616
919.790.1011
http://www.raytheon.com

NXU Front Panel LED's



Adjusting the Input Audio:

The audio input will accept signal levels from –30 to +11 dBm from the connected radio. Internal circuitry is used to amplify or attenuate this input as necessary to optimize the level. The signal level is adjusted by the IN LVL potentiometer accessible from the rear panel. The input is set to 0 dBm when shipped. Test point, TP1, is provided at the rear panel so the actual audio signal voltage applied to the A/D converter can be measured with an AC voltmeter. The correct level for best operation as measured at TP1 is about 0.2V or –12dBm (600 ohm reference).

If an AC voltmeter is not available, observe the AUDIO INPUT LED while programmed audio is present from the connected radio. The AUDIO INPUT LED should flash momentarily at each voice peak. Make appropriate adjustments using the IN LVL potentiometer.

Adjusting the Output Audio:

The audio output from the NXU is a low impedance (10 ohm) unbalanced AC coupled output, which is to be routed to the radio through the interface cable. The output level is adjusted by the OUT LVL potentiometer accessible from the rear panel. This output provides a 0 dBm nominal level; +15 dBm clipping into a 600 ohm load. The audio output will supply signal levels from –30 to +11 dBm. Make adjustments necessary to properly modulate the connected radio.

COR Input Control Signal:

The COR input on J7 controls the RoIP data across the network. If a unit has an active COR input, that unit's audio input will be transferred across the network and will appear at the audio output on J7 at the other NXU unit at the remote end. As long as the COR input of this NXU remains active, the PTT output will remain active on the unit it's connected to. The audio channels are independent, and full duplex operation is possible. If the radio or other audio equipment does not have a COR output, it's possible to tie the NXU COR input line to the active state so that data will be transmitted continuously.

VOCODER Selection:

The NXU uses VOCODER algorithms to compress the baseband audio when it is converted to RoIP data. This will conserve network bandwidth. For example, some compression methods work well with voice and provide a high amount of compression, but do not handle signaling tones very well. Other methods handle tones and voice, but use more network bandwidth because they offer less compression. You may select the method from the following voice compression schemes that optimizes the trade-offs for your particular application. Note both NXUs in the link must use the same VOCODER:

1. GSM 13Kbps - Suitable for voice communications only. Should not be used if any tone signaling is required. Offers the greatest compression with reasonable voice quality. This is the default setting.
2. ADPCM 16Kbps – Suitable for voice or tone signaling. Offers good voice compression, but the voice quality is lower than the other compression methods.

Raytheon
5800 Departure Drive
Raleigh, NC 27616
919.790.1011
http://www.raytheon.com

3. ADPCM 24Kbps – Suitable for voice or tone signaling. Offers less compression than ADPCM 16Kbps but the voice quality is higher.
4. ADPCM 32Kbps – Suitable for voice or tone signaling. Offers still less compression, but the voice quality is the best of the ADPCM compression types.
5. PCM 64Kbps – Suitable for voice or tone signaling. Offers the highest quality of all compression methods, but provides the least compression. *You should use this method only if your network offers low latency and good throughput*.

Refer to the NXU Installation and Operations Manual for further installation and operations information.

Conclusions

In a Mesh network, using the NXU as a *Client* is the easiest and most versatile way to implement the RoIP solution. The *Client* is programmed to obtain its IP address from a DHCP server, usually a function of the network router. The gateway nodes on a Mesh Network generally provide that function.

The user should confirm there is sufficient bandwidth on the Mesh Network. Depending on the vocoder used, 56kbs is generally sufficient. However, on the fringes of a Mesh Network, where traffic must utilize several hops to get to a gateway node, bandwidth may suffer. Although network latency generally increases as well, as long as it remains <100mS, there should be no issues.

An NXU configured as a *Server* requires a static IP address which is difficult to obtain and implement due to the nature of Mesh networks. For reliability, Raytheon recommends use of the NXU as a *Client* in Mesh networks.

Once the NXU, Network Extension Units are configured and installed, they will provide an audio and control signal pathway between a remote located transceiver and a central location. Using existing network infrastructure can make this an extremely cost effective solution.

Acronyms

ADPCM: Adaptive Differential Pulse Code Modulation, is a form of Voice Coding and Decoding algorithm used by the NXU

COR: Carrier Operated Relay, is a signal from a receiver that indicates when a carrier or signal is being received and that the receiver is unsquelched.

GSM: Global System for Mobile Communications, is a form of Voice Coding and Decoding algorithm used by the NXU

ISDN: Integrated Services Digital Network, is a digital telephone connection that uses digital signals instead of analogue signals to handle the transfer of signaling and speech.

NXU: Network Extension Unit, is a device used to connect a DSP-1 module or a four-wire device (such as a radio) over an IP-based network. The unit creates a network link that passes both voice and control signals in the form of RoIP.

PCM: Pulse Code Modulation, is a form of Voice Coding and Decoding algorithm used by the NXU

Raytheon
5800 Departure Drive
Raleigh, NC 27616
919.790.1011
http://www.raytheon.com

PSTN: Public Switch Telephone Network, which refers to the international telephone system based on copper wires and switched circuits for carrying analog voice data.

PTT: Push-to-Talk, A signal to a radio transmitter, which controls the actual transmission of radio frequency energy over the air.

RoIP: Radio over Internet Protocol, (compared to VoIP) not only converts voice to a digital format that can be sent over the Internet or other IP based network, but also convert PTT and COR control signals that are essential for seamless for radio interoperability. Also include are extra delay and jitter compensation.

TCP/IP: Transport Control Protocol / Internet Protocol, is an additional layer to the Internet Protocol, which ensures delivery of packets, sent across the network. It can handle situations such as lost packets or packets arriving out of order.

Vocoder: Voice Coder / Decoder, is an algorithm use by the NXU that reduces speech signals to slowly varying signals transmittable over TCP/IP networks to conserve network bandwidth.

VoIP: Voice over Internet Protocol, is a method of sending voice communications across a digital network.

References

NXU Installation and Operation Manual, P/N 5000-600200, Revision 3.1, Raytheon.

Raytheon
5800 Departure Drive
Raleigh, NC 27616
919.790.1011
http://www.raytheon.com