NXU Point-to-Multipoint Multicast Communications

Purpose

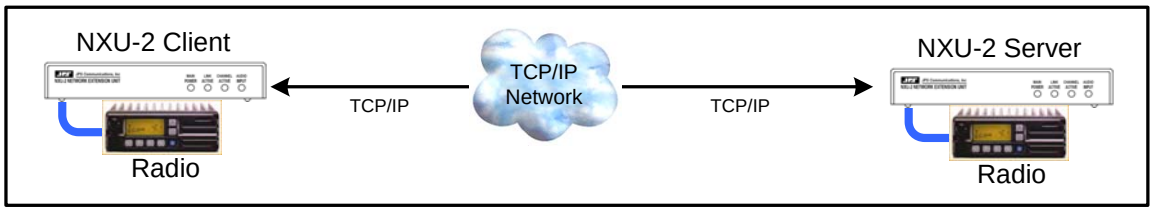
This application note will describe a method at which Raytheon's Network eXtension Unit (NXU) can be utilized to provide Point-to-Multipoint VoIP/RoIP communications, also known as Multicast.

Introduction

The primary function of an NXU Network Extension Unit is to convert analog baseband audio into VoIP/RoIP data, and then transport this digitized audio over a TCP/IP network to another remote located NXU or DSP-2 module.

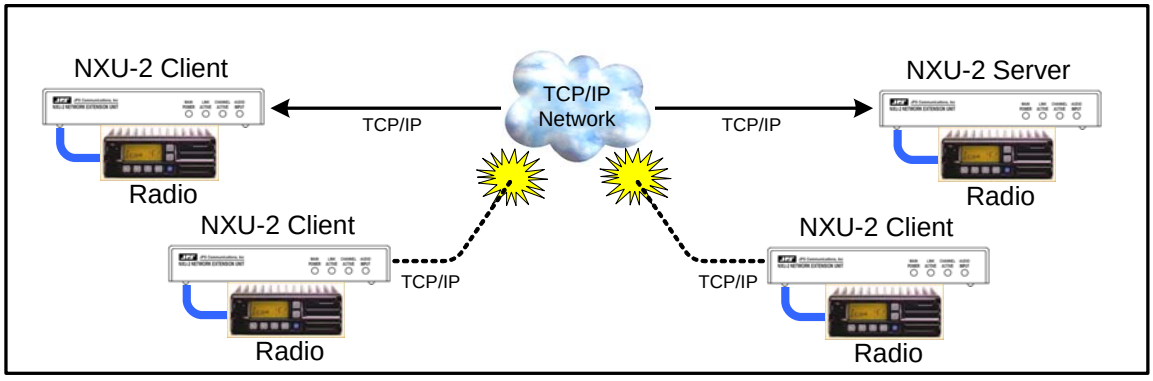
Two NXU units can be associated on a TCP/IP network by assigning one NXU as a CLIENT and the other NXU as a SERVER. This creates a dedicated point-to-point connection where VoIP/RoIP data can flow in *Unicast* fashion. Unicast is a network data communications technique that allows data sharing between two address specific hosts, and only between those two hosts. Unicast is the most common data transport method used in our day-to-day networking LAN and Internet applications, which include TCP and UDP data transport.

Successful Unicast Link



However, if one needs to add one or more additional NXU's to the existing Unicast link to share the same VoIP/RoIP data, the sharing of data will not be possible, because Unicast is a point-to-point protocol.

Failed Unicast Links



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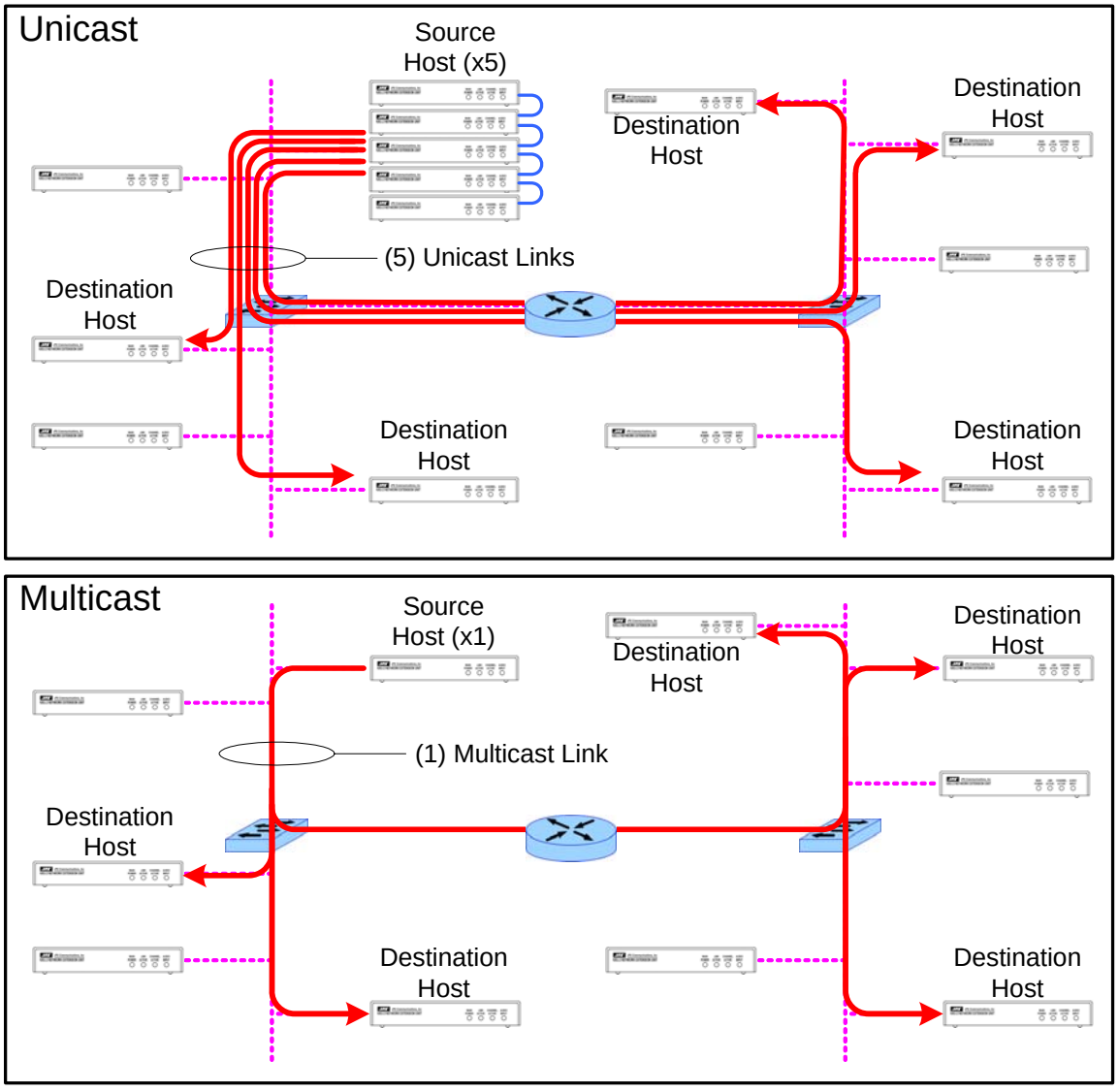
Requirement

Allow three or more NXU units to simultaneously share VoIP/RoIP data using Multicast techniques.

Solutions

IP *Multicast* is a network technique that allows a single source to forward its data to many specific destination hosts. Unlike Unicast, where a single source forwards its data to another single host (point-to-point), Multicast (point-to-multipoint) can effectively reduce the traffic load on a network by reducing the many network paths required by the Unicast data distribution method.

Unicast vs. Multicast



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In terms of the NXU, not only does Unicast create network congestion (see previous diagram), but Unicast requires (5) source host NXU's to support the (5) destination hosts.

Raytheon's VoIP/RoIP capable products, by default, function in Unicast mode. Point-to-point network associations between the following modules are common:

- NXU to NXU
- NXU to DSP-2
- NXU to PCNXU
- DSP-2 to PCNXU
- DSP-2 to DSP-2

IP Multicast is a multifaceted networking algorithm that is defined by many mystifying protocols that encompass legacy and emerging techniques, of which will not be addressed in this application note. However, we will discuss some of the basic principles with regards to the NXU and multicasting of its VoIP/RoIP data, and how we can create successful multicasting applications that can be useful in land mobile radio communications.

Basic IP Multicasting

IP Multicasting simply allows a source-host to forward its data packets to more than one destination-host on the network. There are two basic techniques:

- Source Specific Multicast (SSM) – SSM is a multicast technique that consists of a single host that is the source of the data. The data from this source is forwarded to many specific destination hosts defined by a *Multicast Group*. SSM is similar to over-the-air television broadcast, however instead of sending the data to every destination, only specific destinations within the group will receive the transmission. In Multicasting this group is also known as a *Channel*.
- Any Source Multicast (ASM) – ASM is a multicast technique that does not consist of a specific source-host, however any host within the *Multicast Group* or *Channel* can become a source-host, at anytime. ASM is similar to land mobile radio communications; when a user keys his or her radio, all others will receive the transmission; and all other radio users have the same source and destination privileges.

SSM and ASM are the basic concepts of data multicasting, and are further shrouded by other protocols and algorithms. NXU's use the ASM multicasting technique to share its VoIP/RoIP data.

Multicast Groups:

Multicast Groups are essential to successful sharing of data. In order for a destination host to be eligible to receive multicast data it must become part of the Multicast Group. Other Multicast Groups can exist on the same network, however they cannot share their data across dissimilar groups. In a multicast application the NXU uses a Multicast Group ID to associate itself with other multicast NXU's and DSP-2's. This Multicast Group ID is defined by entering an IPv4 multicast IP address in the [Server IP] or [Remote IP] field of the Web Configuration page of the NXU.

Routing of Multicast Data:

Multicast data traffic can readily be exchanged between source and destination hosts if the hosts belong to the same Multicast Group, but they must reside within the same subnetwork, LAN or Ethernet. In other words, if the hosts do not need to forward data through a network router to a neighboring network segment or to the Internet, then in most cases, sharing of multicast data does not require any special network considerations.

Some network devices, particularly routers, block multicast traffic to reduce network congestion. There are special Multicast Routers that will accommodate multicast traffic, but they still provide a

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level of policing to help reduce unnecessary network traffic and bottlenecks. These special Multicast Routers will readily receive data from multicast source hosts, however it is the responsibility of the destination host to report to the Multicast Router that it can indeed receive multicast data. These network devices must support Level-2 Multicast traffic.

Internet Group Management Protocol (IGMP):

IGMP (Internet Group Management Protocol) is the reporting protocol that a destination host uses to tell the Multicast Router that it can receive multicast data. When the Multicast Router receives data from a source host it checks the packets for the Group ID. The router then forwards the data to all the destination hosts in the remote network segment that share the same Group ID. If no destination host exists, the multicast data is discarded. It is also important to note that Multicast data is UDP (User Datagram Protocol), meaning it is an unreliable transport method using “best effort”, and dropped packets are not retransmitted, as in TCP (Transmission Control Protocol) which is a reliable transport method.

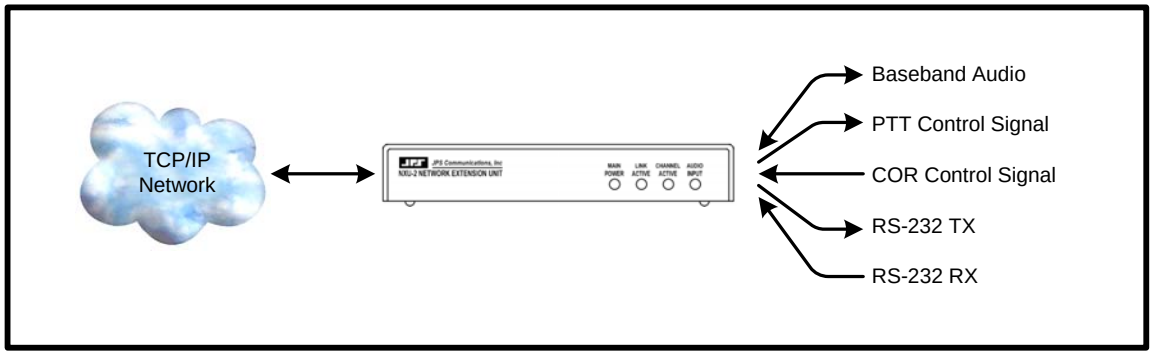
NXU Multicast Address:

Devices that utilize Unicast data transmission use either Class A, Class B or Class C IP address. Multicast devices must use Class D IP addresses, exclusively. The range of Multicast IP addresses that can be used by the NXU are 224.0.0.0 to 239.255.255.255. The three-least significant octets at the right of the IPv4 address are the Multicast Group ID. Again, the Multicast address is defined by entering an IPv4 multicast IP address in the [Server IP] or [Remote IP] field of the Web Configuration page of the NXU.

The NXU Network eXtension Unit:

Raytheon’s NXU Network Extension Unit is a standalone device that interfaces full-duplex baseband audio, (1) RS-232 port and (4) status bits onto a TCP/IP Ethernet network. The NXU uses RoIP (Radio Over Internet Protocol) to convert land-mobile radio baseband audio to datagram, which can then be routed over an existing digital network. The NXU can also address the essential control signals used by land-mobile radio systems. These control signals consist of the COR signal generated by a device when it is receiving a radio transmission, and the PTT signal which requests a device to begin a radio transmission. VoIP alone cannot handle these control signals, and that is why RoIP, used by Raytheon, is essential to providing compatibility to land-mobile radio systems. The following diagram illustrates the signals that can be transported over a TCP/IP network.

NXU Functions



NXU units are network devices, meaning they can be identified over the network with unique IP addresses. Two NXU’s in *Normal Mode* can be associated across a TCP/IP network by assigning

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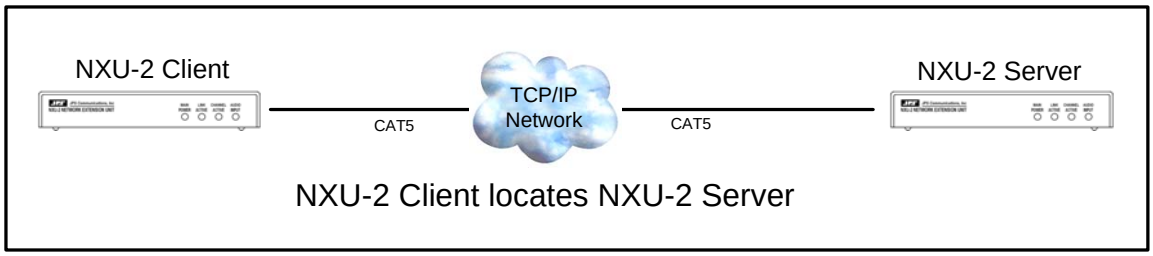
one NXU as a *Server*, and the other NXU as a *Client*. The purpose of the *Server NXU* is to wait on the network for a *Client NXU* to connect to it. The purpose of the *Client NXU* is to locate and connect to a specific *Server NXU* over the network. Since the *Server NXU* has a unique IP address, we can tell the *Client NXU* to associate or connect to the *Server NXU* using the server's IP address. Once the association is established (typically within 5 seconds) RoIP traffic can commence in full duplex fashion.

Conversely, in Multicast Mode, all NXU's are configured as Clients, and no Servers can communicate to any Multicast Client NXU's.

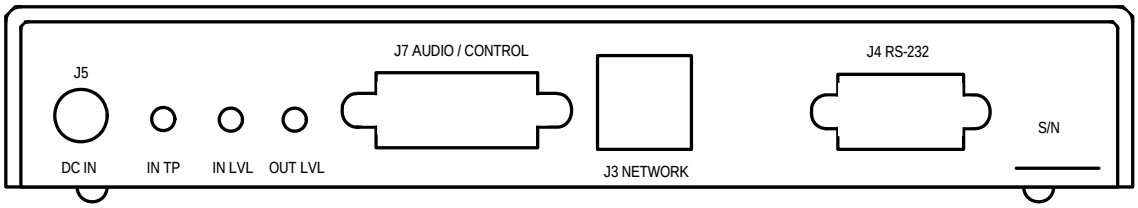
NXU Client / NXU Server Association



The NXU has (3) primary connections:

- J3 – RJ45 TCP/IP Network Connection, 10 mb/s Ethernet. Able to connect back-to-back NXU's 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. 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.

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

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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.

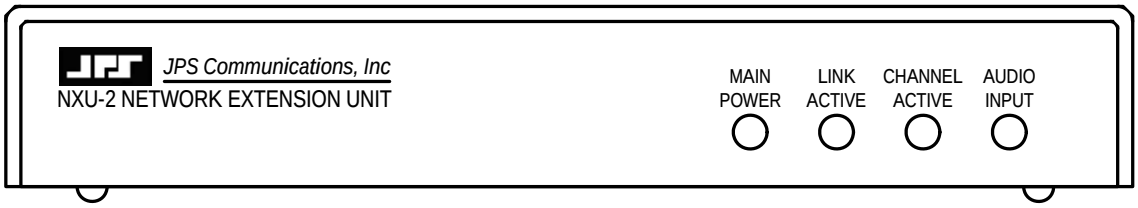
Network Configuration of Multicast NXU:

It is imperative that the network be configured such that all NXU's have network visibility between themselves, otherwise the Multicast link will not be possible.

- Server NXU: Multicast applications do not use Server NXU's.
- Client NXU: The Multicast NXU must have a unique IP Address, and be configured as a CLIENT and MULTICAST MODE. Additionally, all Client NXU's must all have the same Multicast Group IP address entered in the "Serve IP Address" field.

If the devices are configured correctly the Link Active LED on each of the Multicast NXU's will be lit.

NXU Front Panel LED's:



Configuring the NXU for Multicast:

Many older Raytheon VoIP/RoIP devices (NXU, DSP-2, etc.) may have been deployed into the field with firmware that does not support Multicast. If you are unsure whether the current firmware in the unit will support multicast operations contact Customer Support to obtain the latest multicast firmware via email or file download at no cost.

All NXU's that will be multicasting VoIP/RoIP data, whether they reside on a local network segment or network segments separated by network routers must all have unique IP addresses and must have network visibility to each other at all times. Network connectivity between the

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Multicast NXU's is by far the most difficult part of multicast communications. Perform the following steps to each of the Multicast NXU hosts:

Step 1: Launch the Web Configuration page of the NXU.

Step 2: Configure the IP Address, Subnet Mask, Gateway, etc as usual.

Step 3: Under "Unit is", select [CLIENT]. All Multicast NUX-2's must be Clients.

Step 4: Under "Communications Mode", select [MULTICAST].

Step 5: Select a Multicast Group IP Address between [224.0.0.0] and [239.255.255.255], and enter it in the "Remote IP" field. Remember, this IP address will be used with all hosts in the Multicast Group. There can be more then one isolated Multicast Group on a network.

Step 6: Select a port number between [1025] and [65536], and enter it in the "Audio Port" and "Remote Port" fields. It will also be important that the routers supporting this network be able to forward the data on the selected port numbers.

Step 7: Select a common VOCODER to be used by all NXU's in the Multicast Group. GSM 13kbps should be adequate.

Step 8: Repeat Step 1 through Step 8, for each NXU.

Step 9: Verify that all NXU's have a valid LINK ACTIVE LED. If the LINK ACTIVE LED is not lit, double check the previous steps and verify that all supporting network devices (routers, switches, etc) support IGMP Multicast traffic, Level-2 Multicast, and have common network visibility.

If there are audio sources connected to the J7 audio connection of the NXU, multicast audio should be heard between all associated NXU's in the Multicast Group. Note: DSP-2 modules in HYBRID mode or STANDALONE mode, as well as the PCNXU, can all be setup in Multicast Mode to communicate with each other, similarly to the NXU's described earlier.

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

Conclusions

By employing Multicast-networking techniques, Raytheon's NXU, Network eXtension Units, not only reduce network congestion and traffic, but can also lead to many unique point-to-multipoint applications that can be appropriate for land mobile radio communications.

Acronyms

ASM: Any Source Multicast is a multicast technique that does not consist of a specific source-host, however any host within the Multicast Group can become a source-host, at anytime.

CAT5: An Ethernet cable standard that is the 5th generation of twisted pair Ethernet cabling and the most popular of all twisted pair cables used today.

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.

IPv4: Internet Protocol version 4 is the current version used for IP addressing. IPv4 addresses are 32 bits wide [nnn.nnn.nnn.nnn] limiting IP addresses to 4.2 billion variations.

IPv6: Internet Protocol version 6 is in the experimental version used for IP addressing. IPv6 addresses are 128 hex bits wide [hhhh: hhhh: hhhh: hhhh: hhhh: hhhh: hhhh: hhhh /64] limiting IP addresses to 340 undecillion (1036) variations

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NXU: Network Extension Unit, is a device used to connect a DSP-1 module or a land mobile radio device 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

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.

RS232: Recommended Standard 232 is a specification for serial communications between a computer and modem, or computer to other device to be controlled.

SSM: Source Specific Multicast is a multicast technique that consists of a single host that is the source of the data packets. The data from this source are forwarded to many specific destination hosts defined by a Multicast Group.

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.

TCP: Transmission Control Protocol TCP enables two hosts to create a connection and exchange data. TCP guarantees delivery of data. See UDP.

TXD: Transmit Data, is an RS-232 designation with respect to data flow.

UDP: User Datagram Protocol is connectionless protocol that runs on top of IP networks. UDP provides minimal error recovery features, instead provides a direct method to forward datagrams over a network, and consuming minimal network bandwidth. See TCP

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.

RFC1112 - Host Extensions for IP Multicasting, Network Working Group, August 1989

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