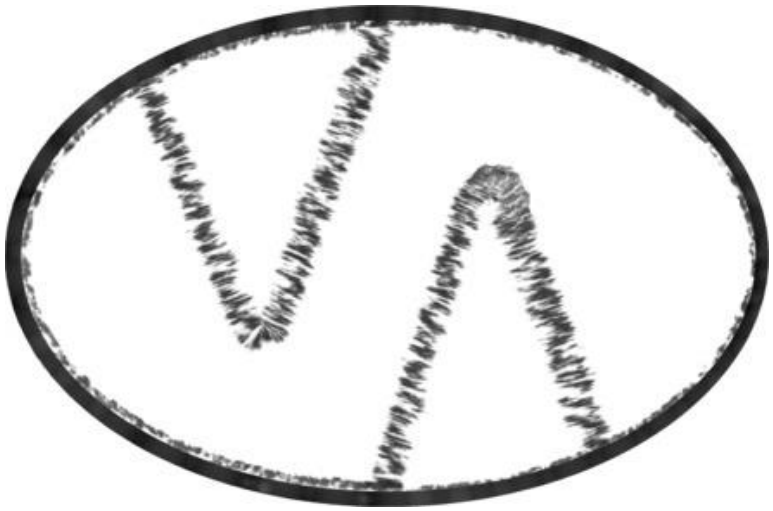

Phase 4 Design, Inc

VoIP / RoIP for Technicians

Presented by
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Notes

Table of Contents

Table of Figures

What are we going to discuss today

Topic for today / Agenda

Cover the aspects of VoIP vs RoIP

Examine Potential Solutions

Cover the aspects of the VoIP / RoIP Network Interface

Discuss Network Requirements for RoIP

About Us

Dave Grant – Instructor / dave@phase4.org

Mike Grant – Producer – Student Coordinator / mike@phase4.org

Phase 4 Design, Inc. has been serving the telecommunications industry since 1990. We are located in the Pacific Northwest and we serve customers all across the US. Dave started working in 2-Way Radio in 1972.

In 2009-2010 we retooled the company to focus on custom Telex RoIP integration, training and support, including SIP Phone Systems.

Since then we have developed online training classes for Telex RoIP and Basic 2-Way Radio. These classes are live and interactive with multiple HD cameras during online labs. Mike joined us in mid-2016 as the online class Producer and Student Coordinator.

In 2016 our work with the Washington State Department of Fish and Wildlife was a feature article in *MissionCritical Communications Magazine*, November/December 2016 issue.

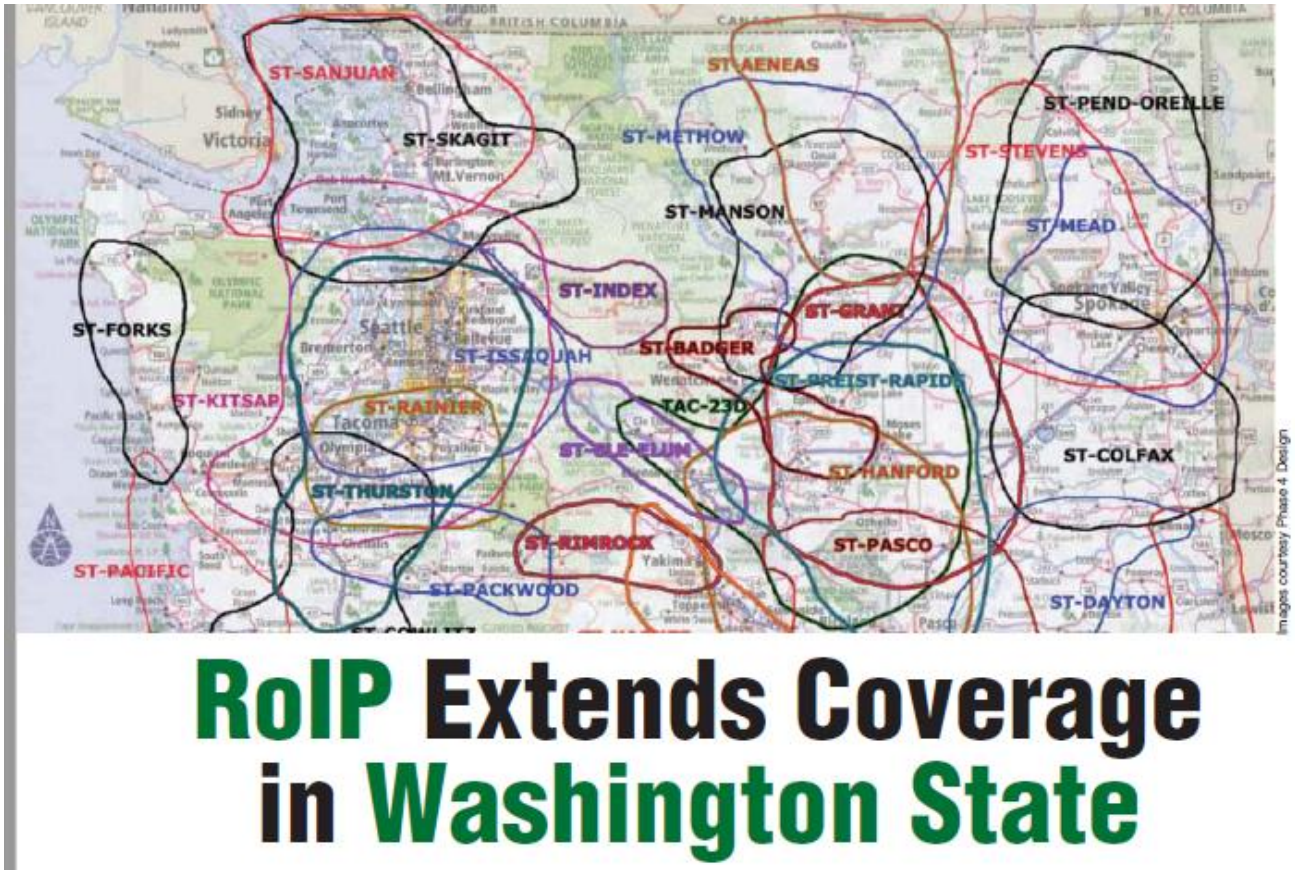

Figure 1 Featured in MissionCritical Communications Magazine

May 2019 WDFW Feature Article

Washington State Department of Fish and Wildlife (WDFW) Telex RoIP Dispatch Center attains PSAP status

Targeted Technology Integration allows WDFW to achieve full Statewide PSAP status for Wildlife incidents in just over 2 years.

Adding SIP, Smartphone integration via ETAC and Man Down Emergency

Figure 2 Next Phase for WDFW

About You

Radio Experience

Anyone have RoIP Experience?

Anyone have IT Experience?

Anyone have an example system to use?

What do you want to get from this session?

Basic Premise

What is the difference between a VoIP and a RoIP System?

How do we interface our RoIP or VoIP System to the network?

VoIP[1] v RoIP[2]

VoIP

- **Mission**
  - Provide for the delivery of Voice Calls via IP Networks
  - Provide support of Advanced PSTN and Mobile Features
  - Provide PTT services to Land Mobile Radio via IP Networks

- **Standards**
  - Vonage, Comcast, IMS, Skype, Cisco, Avtec, Zetron

[1] VoIP - Voice over Internet Protocol
[2] RoIP - Radio over Internet Protocol

- **Protocols**
  - Session Initiation Protocol (SIP) RFC 3261
  - H.323v2 (International Telecommunications Union)
  - RTP (Real Time Protocol)
  - Internet Group Management Protocol Version 3
  - Multicast Listener Discovery Protocol Version 2 (MLDv2) for Source-Specific Multicast
  - Multicast VoIP
  - Differentiated Services Code Point (DSCP)
  - Project 25 Console Subsystem Interface (P25 CSSI)
  - Project 25 Inter Subsystem Interface (P-25 ISSI)
  - Vendor Specific Proprietary Protocols
- **Architecture**
  - Session Based
  - Requires Server or End-Point Negotiation
  - Server exposes a Single Point of Failure

RoIP

- **Mission**
  - Provide PTT services to Land Mobile Radio via IP Networks
  - Provide Enhanced Remote Radio Control via IP Networks
  - Provide IP equivalent to a 2 Wire or 4 Wire Audio Circuit
- **Standards**
  - Bridging System Interface (BSI) Draft
  - APCO P25 DFSI
  - Telex Radio Dispatch Proprietary System
  - Mindshare Radio Dispatch Proprietary System

- **Protocols**
  - RTP (Real Time Protocol)
  - Multicast
  - Internet Group Management Protocol Version 2
  - Differentiated Services Code Point (DSCP)
  - Project 25 Console Subsystem Interface (P25 CSSI)
  - Project 25 Inter Subsystem Interface (P-25 ISSI)
  - Project 25 Digital Fixed Station Interface (P-25 DFSI)
  - Vendor Specific Proprietary Protocols
- **Architecture**
  - Stream Based
  - Static Mapping of End-Points
  - No Single Point of Failure

Ethernet Network Essentials

Open Systems Interconnection Model

Line Standards on the Wire
- Bitrate / Timing
- Voltage levels
- Cable loss
- Pinouts

Ethernet Speeds, data types
- Protocol overhead
- Broadcast
- Multicast
- MAC Address
- Hexadecimal numbers

Basis for LAN, WAN, Internet definitions

OSI v TCP/IP Model
- The function is identical
- The TCP/IP model combines OSI layers 1 and 2 into the Network Layer
- The TCP/IP model combines OSI layers 3 and 4 into the IP Layer

Open System Interconnection Model[3]

OSI Model			
	Data unit	**Layer**	**Function**
Host layers	Data	7. Application	Network process to application
		6. Presentation	Data representation and encryption
		5. Session	Interhost communication
	Segment	4. Transport	End-to-end connections and reliability
Media layers	Packet	3. Network	Path determination and logical addressing
	Frame	2. Data Link	Physical addressing (MAC & LLC)
	Bit	1. Physical	Media, signal and binary transmission

TCP/IP Model shown with colors. Light Green is *Network Layer*, Light Blue is the *Internet (IP) Layer*, Dark Blue is the Application Layer.

[3] Courtesy of Wiki. The TCP/IP Protocol Stack combines Layers 1 & 2 as well as 3 & 4.

Protocols

Protocol Standards for Levels 1 – 7

- ARP, IGMP, NAT, DNAT, NTP, SIP, QoS, VPN, DNS, FTP, SSH, DHCP, POP, SMTP, HTTP are examples of protocols using the OSI Model

What do you need to know?

Subnet - LAN, WAN, VLAN, etc

- Logical group of Network Hosts
- As small as 2 hosts
- Can be over 16,000,000 hosts

End to End - Connection vs. Connectionless

- Setup Time
- Round-Trips
- Header size
- Error tolerance

Package - TCP[4], UDP[5], Multicast, Packets

- TCP is guaranteed delivery
- UDP is catch this if you can
- Multicast is a special type of UDP
- Bandwidth is bytes/packet * packets/sec
- Maximum ~15,000pps on 10Mb Ethernet

[4] UDP - User Datagram Protocol
[5] TCP - Transmission Control Protocol

Host Location

Location - MAC[6] Addressing, IP[7] Addressing

- Every NIC has a unique MAC Address (48 bits)
- Every NIC can have multiple IP Addresses (32 bits)
- Every IP Address has 65,535 ports each for TCP and UDP
- There are special ranges of IP Addresses

- Multicast Addresses
  - 224.0.0.0 – 239.255.255.255
  - (IP Address begins with 1110)
  - Can be Routed

- Non-Routable Intranet Address
  - 192.168.0.0- 192.168.255.255
  - 10.0.0.0-10.255.255.255
  - 169.254.x.x APIPA (Automatic Private IP Addressing)
  - Still Routable on the Intranet

- Everything else is a Routable Internet Address

[6] 281,474,976,710,656 possible MAC Addresses
[7] 4,294,967,296 possible IP Addresses

Subnet Mask

- Subnet Mask defines the size of the subnet
- Used to break up a larger Subnet
- 255.255.255.0 or /24 allows 254 hosts
- 255.255.255.248 or /29 allows 6 hosts

Example
11111111111111111111111100000000 = 255.255.255.0 or /24
11111111111111111111111111111000 = 255.255.255.248 or /29

Host Identification

Unicast Host Name Resolution (Layer 3) - DNS
- Maps a URL (Uniform Resource Locator) to an IP Address
  - www.phase4.org = 50.194.58.225
- IP Address is 32bits
- One IP Address can have many URL's
  - www.hostnw.net = 50.194.58.225
- Depends on a Registrar of Record for Internet Addressing
- Uses Port 53, for both UDP and TCP transactions

Unicast Subnet Address Resolution (layer 2) - ARP
- Hard coded into the Ethernet device
- Unique across the universe
- Maps an IP Address to a physical Ethernet Card
  - 10.0.1.239 = 60:6b:9e:a6:ea:17
- MAC Address – 48bits
- One MAC Address can have many IP Addresses
- Depends on the ARP Protocol to locate a host

Packet Routing

Classful v Classless Network Addressing (layer 3)
- Class A, Class B, Class C, Class D
- Class E 240.x.x.x/4
- CIDR (Classless Inter Domain Routing)
- Divides Classful space into smaller address ranges
- Uses the Netmask to filter packets into subgroups
    - 50.194.58.225/29 = netmask 255.255.255.248
    - A /29 network yields a subnet of 6 host addresses
    - The subnet must be on Network Boundary
    - The subnet will always have a DG and BRDCST Address
    - In effect a /29 network has 4 out of 6 usable host addresses

VLAN (Virtual Local Area Network)
- Generally implemented at Layer 2
- Provides a logical grouping of Ethernet MAC Addresses into a separate subnet
- Requires a managed Layer 2 device to configure VLAN

Unicast Routing
- Requires a single Source and Destination IP Address
- Respects netmask settings
- Supports routing protocols like RIP, OSPF, etc.
- Allows for filtering on IP Address, MAC Address, port and packet type
- Forms the basis for NAT, DNAT, DMZ, Firewall, etc.
- Allows for packet encapsulation protocols
- Provides support for QoS protocols like DSCP, port or address marking
- Does not typically pass Multicast Packets

Multicast Routing

- Not generally supported in Unicast Routers
- Introduces the Listener Host
- MC Branch Addresses maintained by Switch or Router
- MBone (Multicast Internet Backbone)
- Internet Gateway Management Protocol (IGMP)
    - Version 2
    - Version 3
- Direct Address Mapping

A Multicast MAC Address is a combination of an IANA OUI and the Multicast IP Address. (Magic Number)

Multicast Subnet Address Resolution (layer 2)

- Soft coded into the Ethernet Network device
- Ignores netmask, MC is only on subnets with MC Listners
- Unique across the subnet (?)
- Maps an IP Address to a physical Ethernet Card
    - 239.0.0.5 = 01:00:5e:00:00:05
    - 224.0.0.5 = 01:00:5e:00:00:05
- MAC Address – 48bits
- Each MC IP Address has a single MC MAC Address

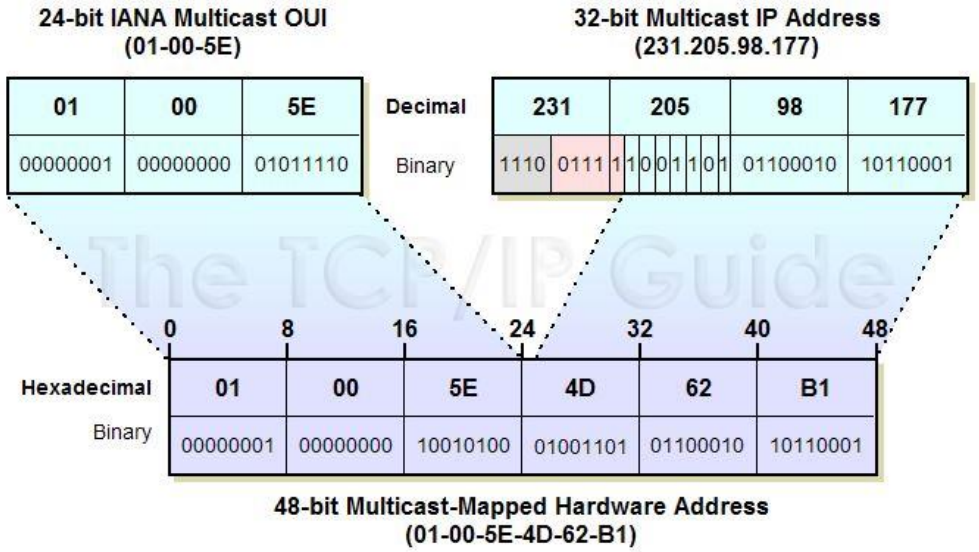

Figure 51: Mapping of Multicast IP Addresses to IEEE 802 Multicast MAC Addresses

IP multicast addresses consist of the bit string "1110" followed by a 28-bit multicast group address. To create a 48-bit multicast IEEE 802 (Ethernet) address, the top 24 bits are filled in with the IANA's multicast OUI, 01-00-5E, the 25th bit is zero, and the bottom 23 bits of the multicast group are put into the bottom 23 bits of the MAC address. This leaves 5 bits (shown in pink) that are not mapped to the MAC address, meaning that 32 different IP addresses may have the same mapped multicast MAC address.

Figure 3 Multicast MAC Creation

Sourced from "The TCP/IP Guide" TCP/IP Address Resolution For IP Multicast Addresses
http://www.tcpipguide.com/free/t_TCPIPAddressResolutionForIPMulticastAddresses.htm
September 20, 2005, Charles M. Kozierok.
Because of the way a Multicast MAC Address is created there is the possibility of different MC Addresses creating the same MC MAC Address.

VPN (Virtual Private Network)

- Typically implemented at Layer 2 or 3
- Normally uses encryption
- PPTP, IPSEC, Proprietary (DCB)
- Creates a virtual flat network for Multicast packets

The network shown below illustrates how a VPN can be created within an existing unicast network. This subnet can have completely different IP Addressing schemes as the host network.

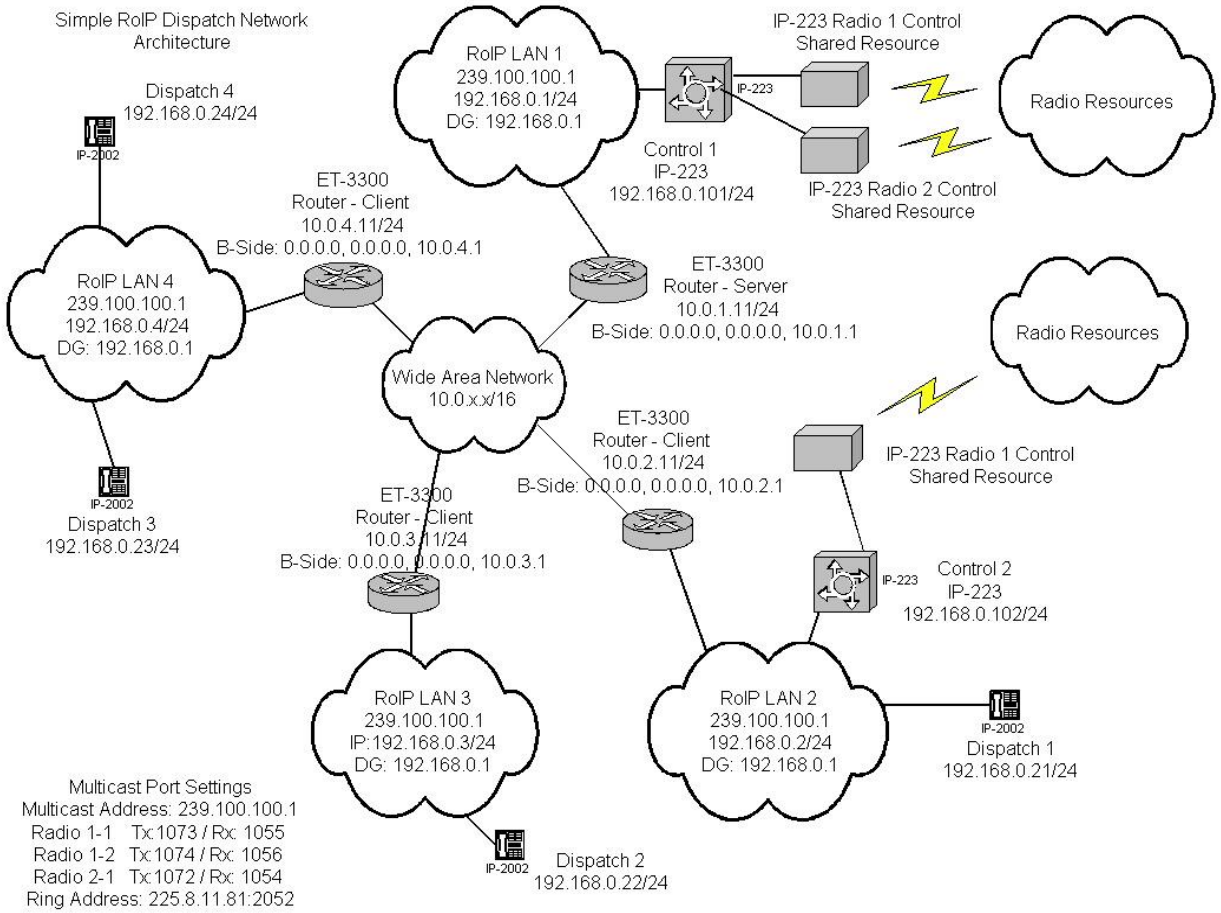

Figure 4 RoIP System using VPN