Essentials for Media-over-IP Network Design

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Agenda

- Introduction

- Media-over-IP (MoIP) Network Design

- Essential Technologies

- Conclusion

Introduction

- Koji Oyama [in] https://www.linkedin.com/in/koji-oyama/
  - Technical Consultant, Evangelist, Hardware/Software Engineer
  - Founder and CEO, Xcelux Design
  - 10+ yrs engineer & 10+ yrs sales/marketing experience
  - Love New Technology 👍

- Xcelux Design, Inc. www.xceluxdesign.com
  - Technical Consulting Company
  - Founded in October 2016
  - Tokyo, Japan ⇄ San Jose, CA
  - Targeting area: IP network infrastructure, AI interpretation

Objective and Goal of this presentation

- Target Audience : Beginners
  - Broadcast engineers who are NOT familiar with IP network technology
  - IT network engineers who WANT to know what else is necessary to learn for MoIP network design

- Objective / Goal of this presentation
  - Obtain the basic knowledge that you need to design a MoIP network
    - 30 mins are not enough to learn whole things
      - you can get hints for learning these technologies
    - if you don't know some key words, you can learn by googling them
      - Based on network common technologies

IP Network

- Physical (Layer 1)
  - Optical Fiber Cables or Copper Cables
    - QSFP28, QSFP+, SFP28, SFP+, RJ-45
    - Multi-mode (For SR: OM3, …), Single-mode (For LR: OS2, …)
  - Optical Transceiver Modules
    - Connectors: LC, MPO …
  - Direct Attach Cables (DAC) / Active Optical Cable (AOC)
- Ethernet frame (Layer 2)
  - Hub/L2 switches : transfer data by destination MAC address within a same segment
  - GbE: 1000BASE-TX, 10GbE: 10GBASE-SR/LR, 25GbE: 25GBASE-SR/LR,
    100GbE: 100GBASE-SR4/LR4/SR10/LR10
- Internet Protocol = IP (Layer 3)
  - Router/L3 switchers : transfer data by destination IP address btw different segments
- TCP/UDP (Layer 4)
  - Usually use UDP for media and TCP for control

L7	Application
L6	Presentation
L5	Session
L4	Transport
L3	Network
L2	Data link
L1	Physical

OSI model

OSI mode: https://en.wikipedia.org/wiki/OSI_model

- Video, audio, and meta data on IP protocols
- Multicast for media and unicast for control
  - IPv4 multicast
  - UDP size specified in SMPTE ST 2110-10
- Receive media data using IGMP when you want that data
  - Based on the manner to send data when needed for network paths that require transmission
  - IGMP v3

Sender A 192.168.10.1
Sender B 192.168.20.3
Sender C 192.168.30.7
Sender D 192.168.30.9

232.100.10.1   232.100.20.3   232.100.30.7   232.100.40.9

Multicast

MoIP Network (media plane)   **PIM-SSM**

L2/L3 NW Switch

IGMP v3

(S,G) = (192.168.10.1, 232.100.10.1)
(S,G) = (192.168.10.1, 232.100.10.1)
(S,G) = (192.168.30.7, 232.100.30.7)

Request To join the group

receiver A   receiver B   receiver C

| No.	Time	Source	Destination	Protocol	Length	Info
75	27.932844	192.168.21.200	224.0.0.22	IGMPv3	66	Membership Report / Join group 232.110.10.7 for source {192.168.10.200}…
367	147.945171	192.168.21.240	224.0.0.1	IGMPv3	60	Membership Query, general
374	150.245274	192.168.21.200	224.0.0.22	IGMPv3	66	Membership Report / Join group 232.110.10.7 for source {192.168.10.200}…
619	272.992702	192.168.21.240	224.0.0.1	IGMPv3	60	Membership Query, general
623	274.567850	192.168.21.200	224.0.0.22	IGMPv3	66	Membership Report / Join group 232.110.10.7 for source {192.168.10.200}…
692	299.371722	192.168.21.240	224.0.0.1	IGMPv3	56	Membership Query, general
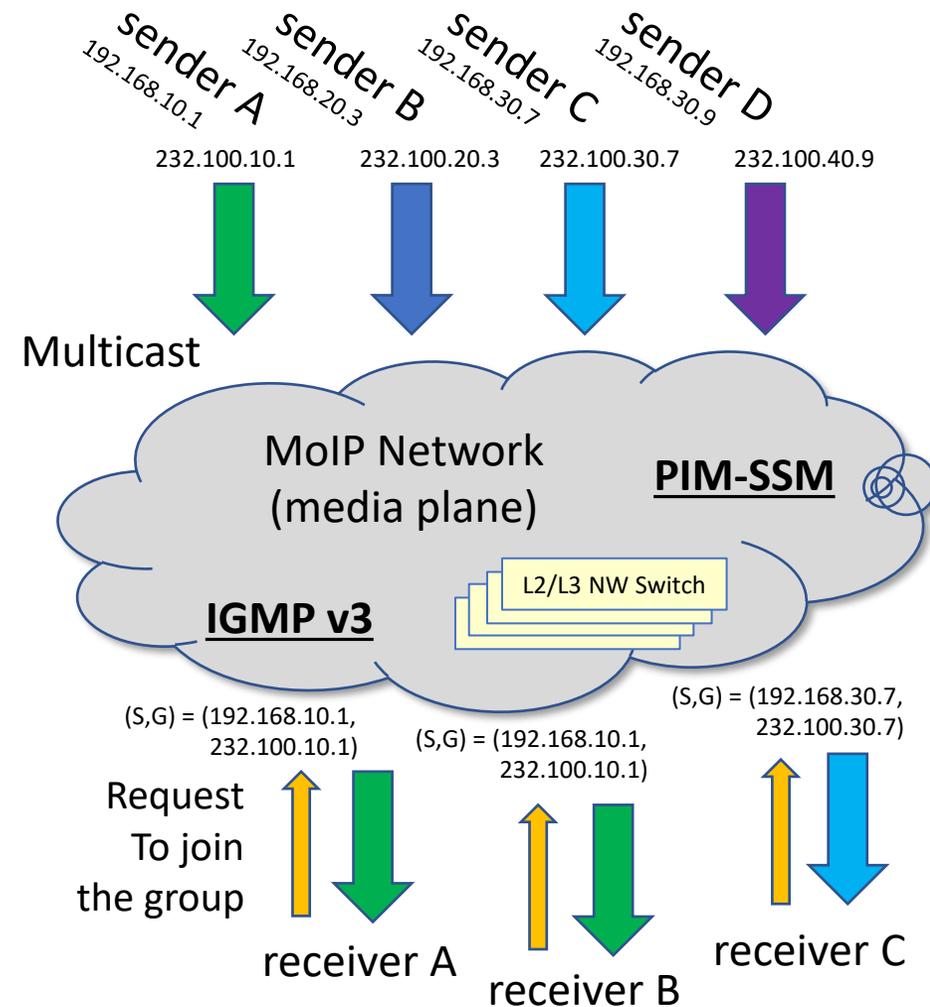
# Media over IP (2)

- JT-NM TR-1001-1:2020
  - http://www.ipshowcase.org/wp-content/uploads/2019/05/1030-Koji-Oyama-20190409_IPShowcase-NAB19_M3L-CurrentStatus-ST2110-over-25GbE_v100.pdf

- Media Node Requirements
  - Comply with SMPTE ST 2110 & ST 2059
  - Implement SMPTE ST 2022-7:2018
  - Expose NMOS IS-04/05 entries
  - Implement AMWA BCP-002-01
  - Implement AMWA NMOS IS-08
  - Utilize IPv4 Multicast addressing for streams
  - Utilize DHCP
  - Store current operating settings
  - Store System ID and DHCP-assigned address, and check at re-start
  - Support the entire range of multicast addresses from 224.0.2.0 through 239.255.255.255.
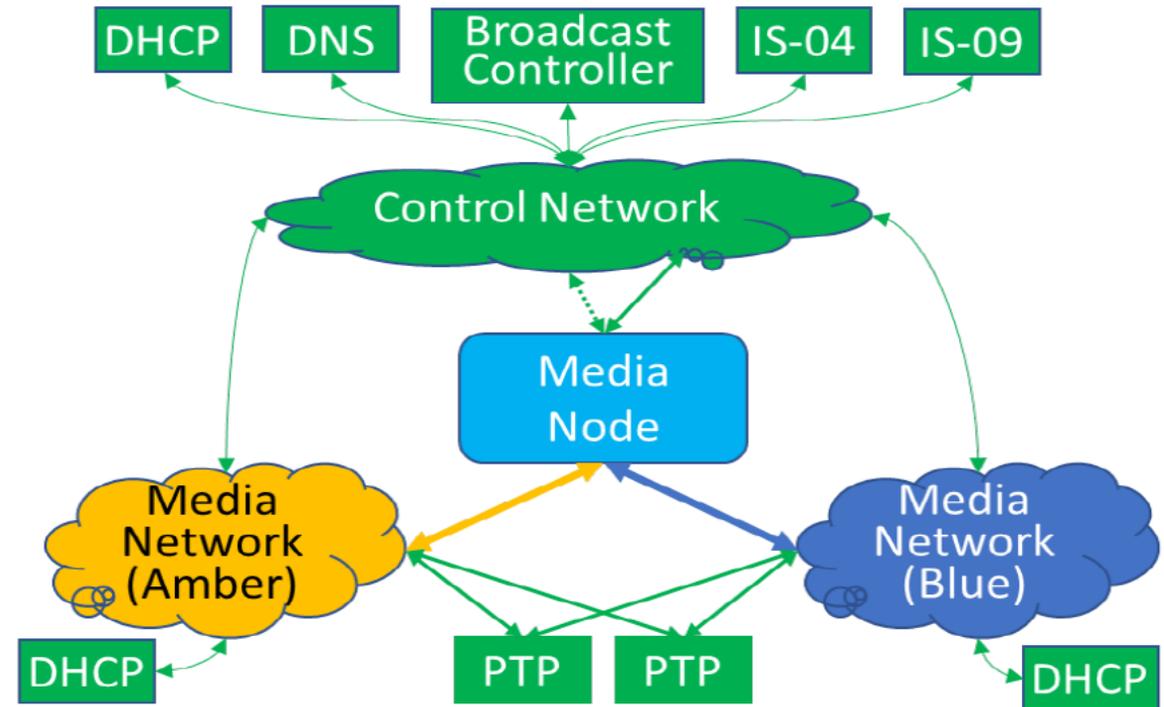
Figure 1 – Abstract Network Environment Diagram

MoIP Network Example

- Production for Video, Audio, Inter-comm
- Spine-Leaf NW switches
  - Non-blocking
- ST 2059 PTP
  - Boundary clock
  - BMCA
- Redundant (ST 2022-7)
- Separated media and control plane
  - Logically / Physically

Media Plane

Grandmaster | Grandmaster

L3 NW Switch | L3 NW Switch

L2/L3 NW Switch | L2/L3 NW Switch | L2/L3 NW Switch | L2/L3 NW Switch

Inter-comm | Inter-comm | Inter-comm

video | audio | playout

L2/L3 NW Switch | L2/L3 NW Switch

Control Plane
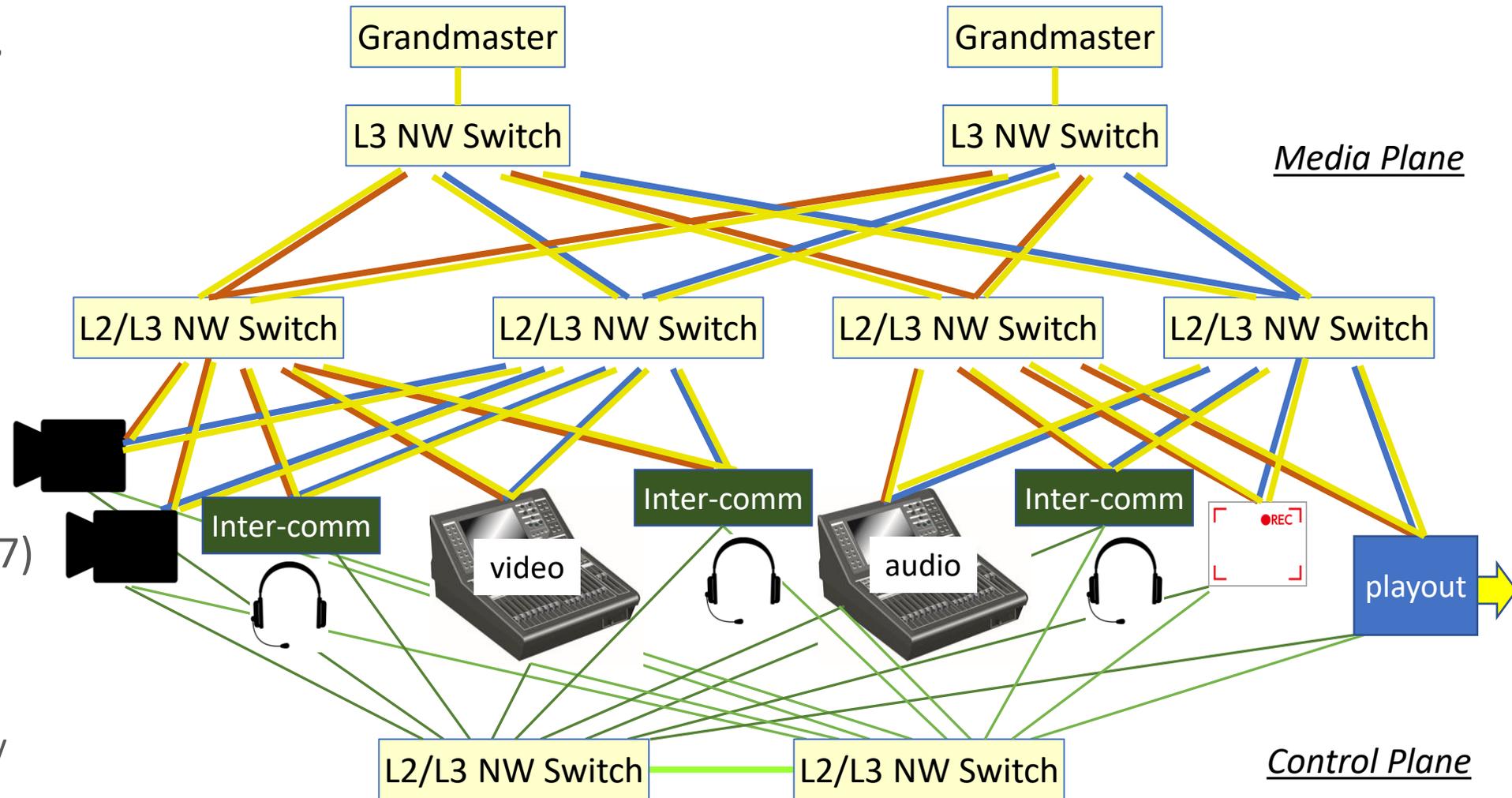
Network L2/L3 Switches

- More functionality: L2 ⇔ L3/L2
- High performance: **Non-blocking**
- **Configurable**: Unmanaged ⇔ Managed
- Resource Sharable: VLAN, VRF
- Redundant Power
- Speed: GbE ⇔ GbE, 10GbE, 25GbE, 40GbE, 100GbE
- Cable: CAT5e/6 Copper Cable ⇔ Optical Cable

Needs to be CONFIGURED more
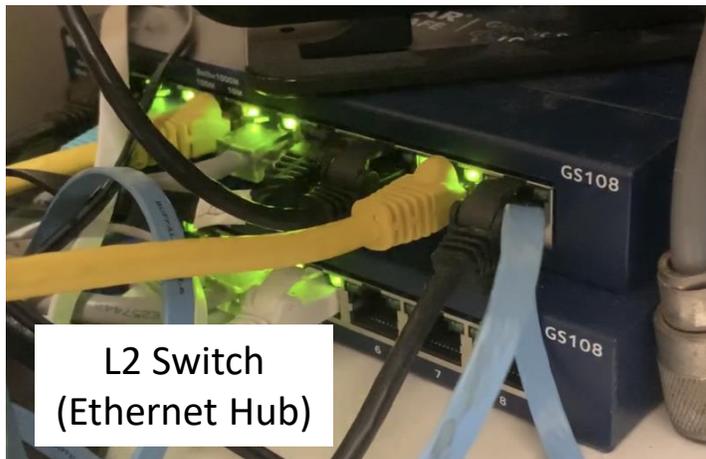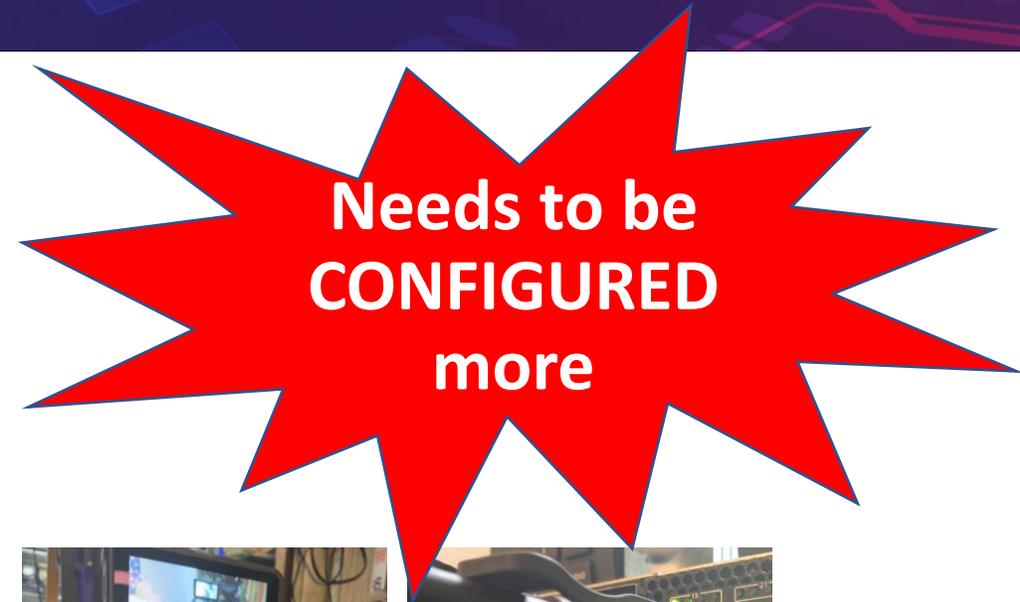
L2 Switch
(Ethernet Hub)

Home Use
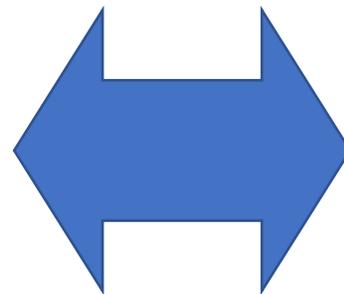
L2/L3 Switch

Data Center Use

MoIP Network Design Flow

- Not only physical but also **logical design** is necessary

- Bottom-up design while verifying the feasibility of a specific functionality w/minimal network configuration is likely to result in faster design / verification convergence.

Physical Network Design

Logical Network Design

List all media and control equipment

List all media and control sessions

Count physical ports of equipment to be connected

Calculate max bandwidth of each sessions

Calculate bandwidth of each ports

Select network switches

assign IP addresses for each sessions and multicast groups

Check behavior using actual network with the minimum configuration

refine the abstract design (logical architecture, isolation, fault tolerance)

Documentation

configure switches

Revise / Modify the specification

Review

Verification (normal/abnormal)

Finish

Configure Network Switches

- The commands to configure NW switches differ depending on the switch vendors and the installed network OS

- Use CLI or GUI to configure a switch
  - via ethernet interface or serial interface

```
interface Vlan123
    ip address 192.168.123.254/24
!
interface Vlan130
    vrf ssm-mapping-test
    ip address 10.130.100.20/16
    pim ipv4 sparse-mode
!
ip routing
no ip routing vrf management
ip routing vrf ssm-mapping-test
!
monitor session Mon51TxRx source Ethernet51
monitor session Mon51TxRx destination Ethernet2
monitor session Mon53TxRx source Ethernet53
monitor session Mon53TxRx destination Ethernet4
!
ip route vrf ssm-mapping-test 10.120.100.0/24 10.130.100.60
!
ntp server ntp.nict.jp
!
router multicast
    ipv4
        routing
    !
    vrf ssm-mapping-test
        ipv4
            routing
!
router pim sparse-mode
    ipv4
        rp address 10.120.100.254
    !
    vrf ssm-mapping-test
        ipv4
            fast-reroute test1
!
```

```
# Auto-generated by NVUE!
# Any local modifications will prevent NVUE from re-generating this file.
# md5sum: 888bd2e4dce17e44xxxxxxxxxxxxx
# This file describes the network interfaces available on your system
# and how to activate them. For more information, see interfaces(5).

source /etc/network/interfaces.d/*.intf

auto lo
iface lo inet loopback

auto mgmt
iface mgmt
    address 127.0.0.1/8
    address ::1/128
    vrf-table auto

auto eth0
iface eth0
    address 192.168.123.61/24
    gateway 192.168.123.1
    ip-forward off
    ip6-forward off
    vrf mgmt
```

```
##
## Interface Ethernet configuration
##
    interface ethernet 1/1 speed 10G force
    interface ethernet 1/2 speed 10G force
    interface ethernet 1/1 switchport mode trunk
    interface ethernet 1/2 switchport mode trunk
    interface ethernet 1/19 switchport mode trunk
    interface ethernet 1/20 switchport mode trunk
    interface ethernet 1/21 shutdown
    interface ethernet 1/22 shutdown
##
## VLAN configuration
##
    vlan 10
    vlan 11
    vlan 110
    vlan 111
    interface ethernet 1/1 switchport trunk allowed-vlan none
    interface ethernet 1/2 switchport trunk allowed-vlan none
    interface ethernet 1/19 switchport trunk allowed-vlan none
    interface ethernet 1/20 switchport trunk allowed-vlan none
    interface ethernet 1/1 switchport trunk allowed-vlan add 10
    interface ethernet 1/1 switchport trunk allowed-vlan remove 1
    interface ethernet 1/2 switchport trunk allowed-vlan add 11
    interface ethernet 1/2 switchport trunk allowed-vlan remove 1
    interface ethernet 1/19 switchport trunk allowed-vlan add 111
    interface ethernet 1/19 switchport trunk allowed-vlan add 110
##
## STP configuration
##
    spanning-tree mode rpvst
##
## L3 configuration
##
    vrf definition Group10
    vrf definition Group20
```

Essential Network Technologies

- VLAN

- VRF

- Multicast routing
 - PIM
  - IGMP

- OSPF

- LAG/LACP

- VRRP

VLAN (Virtual Local Area Network)

- https://en.wikipedia.org/wiki/Virtual_LAN
  - It is a technology to set virtual groups of devices and operate each as if they were one LAN
  - It is any broadcast domain that is partitioned and isolated in a network
- Use for Media Plane or Control Plane, Layer 2
- Port VLAN, Tag VLAN (IEEE802.1Q)
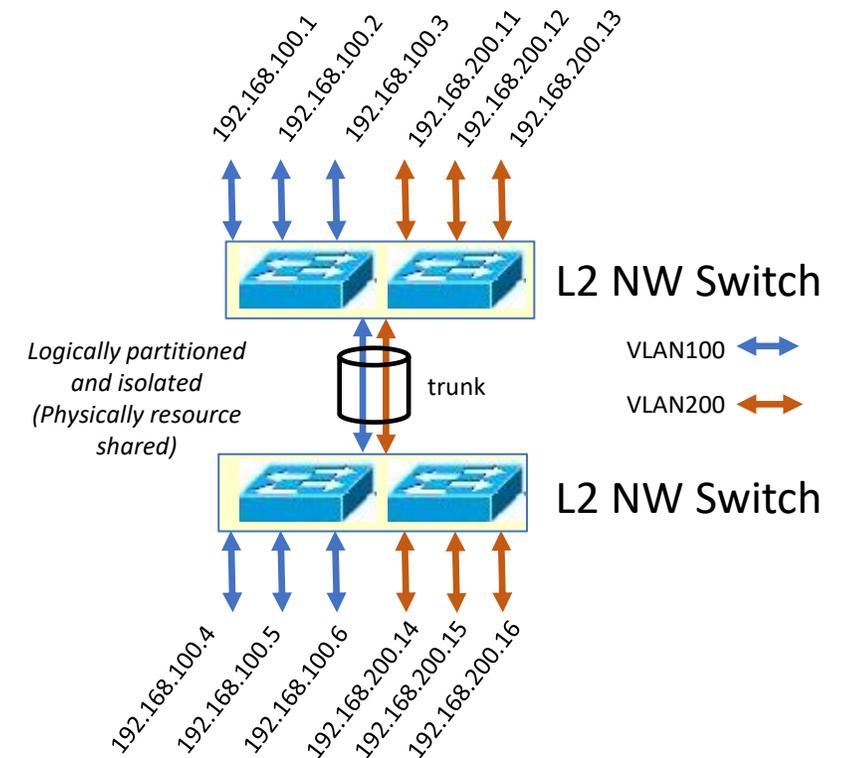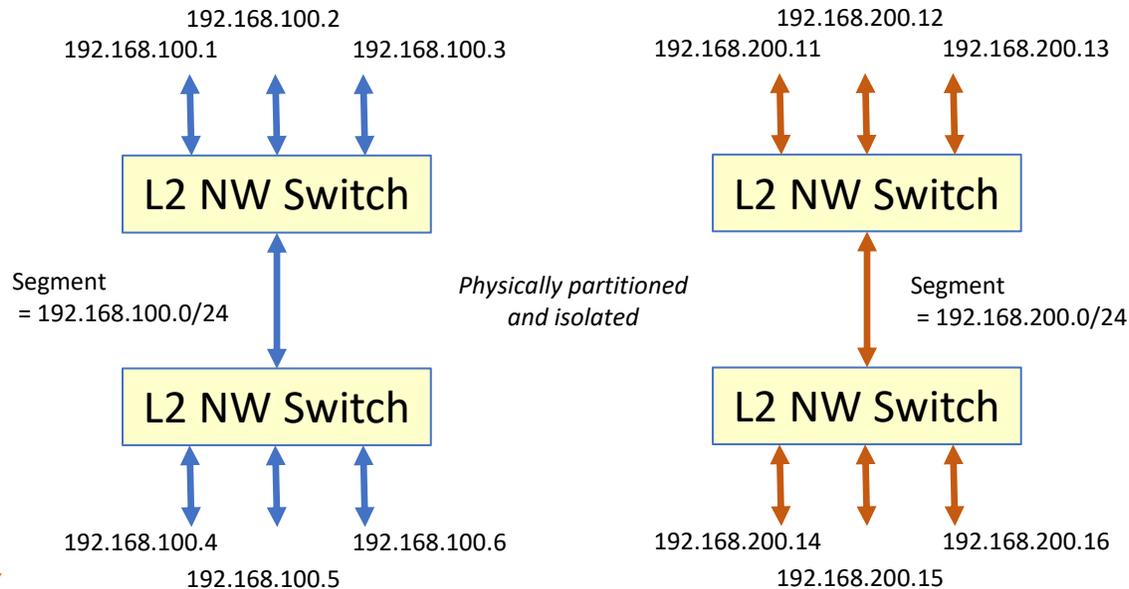
VRF (Virtual Routing and Forwarding)

- https://en.wikipedia.org/wiki/Virtual_routing_and_forwarding
  - It allows you to configure multiple virtual routers in one router.
  - It allows multiple instances of a routing table to co-exist within the same router at the same time

- Use for Media Plane, Layer 3
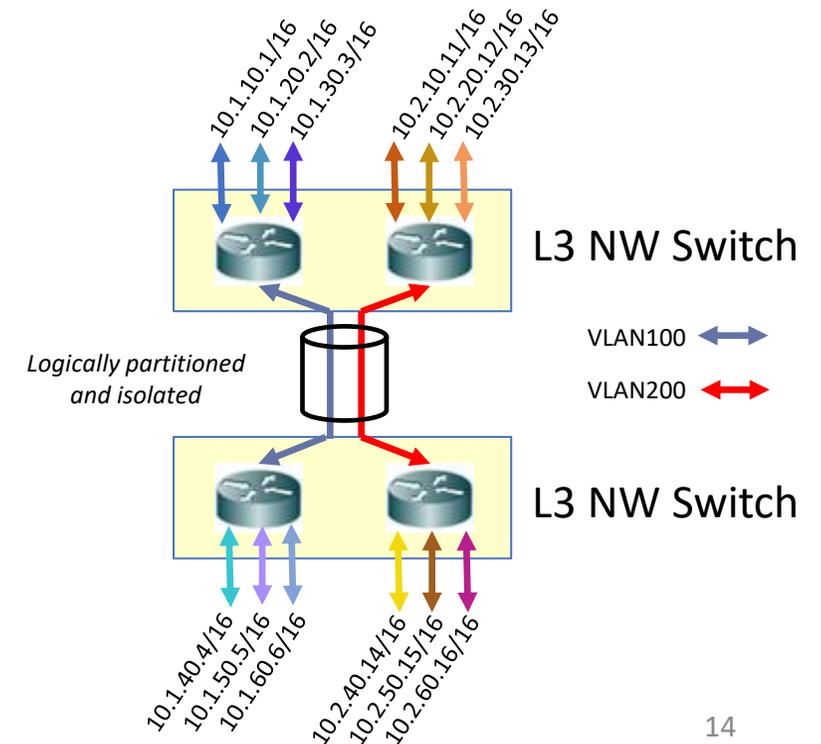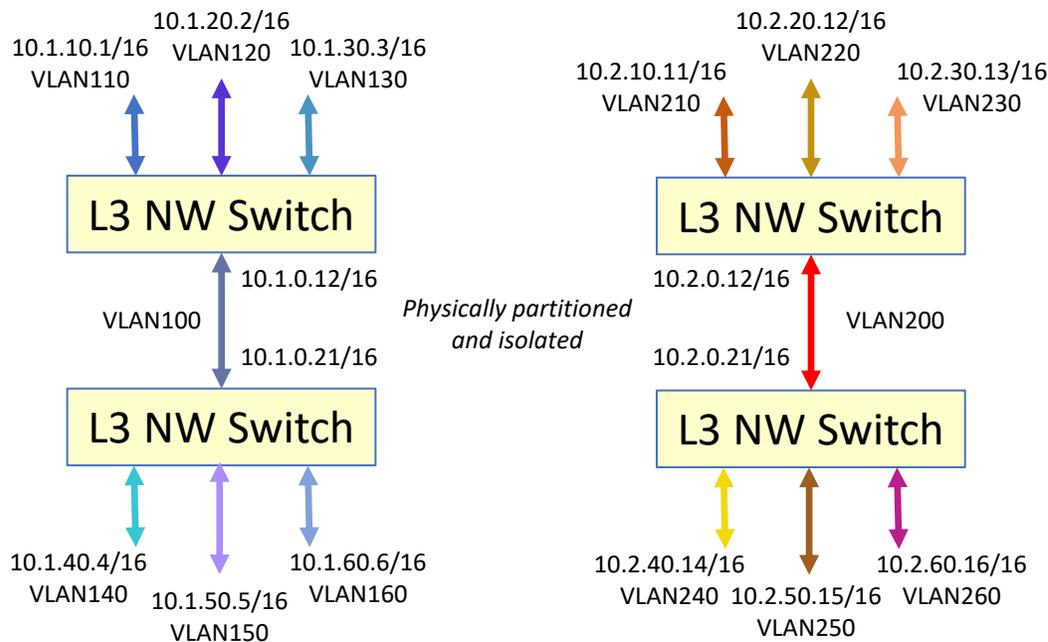
# Multicast routing

- https://en.wikipedia.org/wiki/Multicast_routing
  - a method of transmitting to all subscribers registered in a group by one transmission
- Use for Media Plane
- Multicast protocols: PIM, Multicast BGP, ...
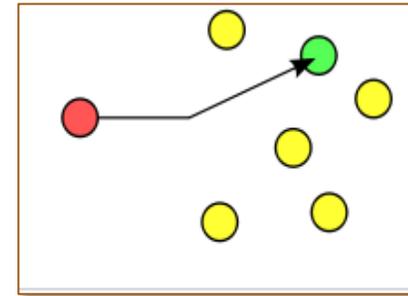
Unicast (one-to-one)
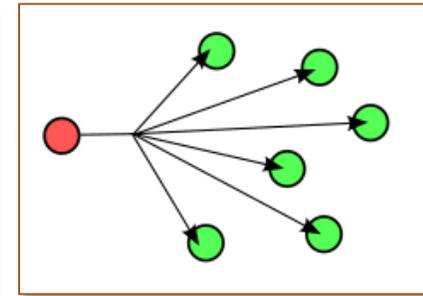
Broadcast (one-to-all)
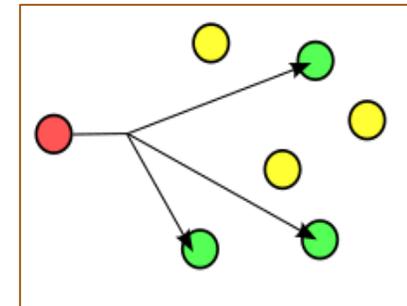
Multicast (one-to-many)
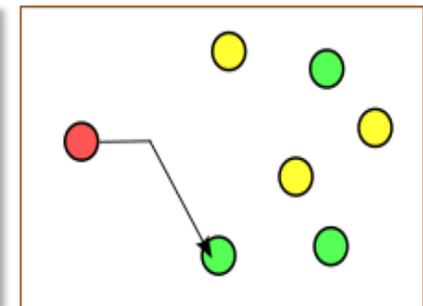
Anycast
(one-to-one-of-many)

Multicast routing: PIM(Protocol Independent Multicast)

- https://en.wikipedia.org/wiki/Protocol_Independent_Multicast
  - One of multicast routing protocol
  - PIM does not include its own topology discovery mechanism → Protocol Independent
- Use for Media Plane
- 4 variants: PIM-SM, PIM-DM, Bidir-PIM, PIM-SSM
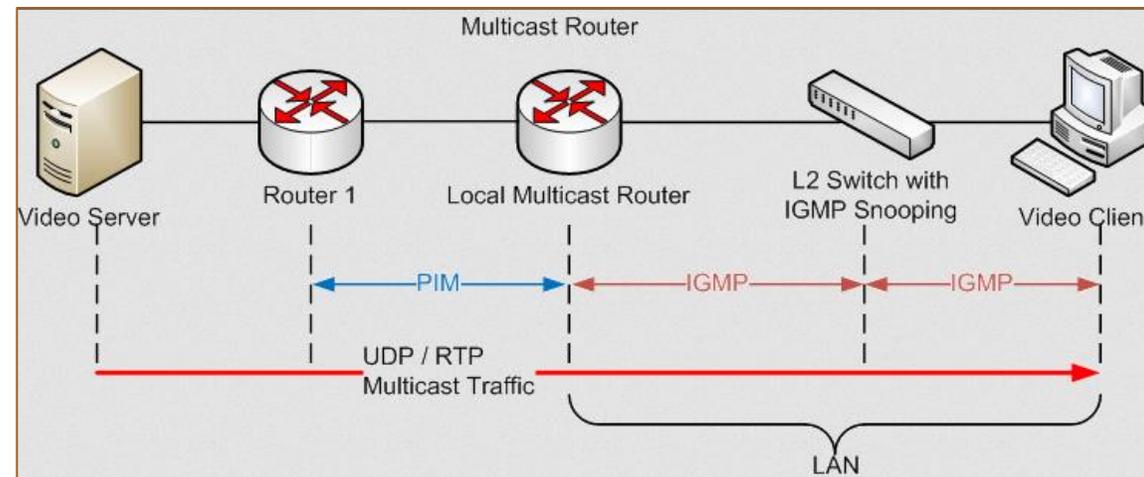
Multicast routing:
IGMP (Internet Group Management Protocol)

- https://en.wikipedia.org/wiki/Internet_Group_Management_Protocol
    - It is a communications protocol used by hosts (receivers) and adjacent routers on IPv4 networks to establish multicast group memberships
    - It allows the network to direct multicast transmissions only to hosts that have requested them
- Use for Media Plane
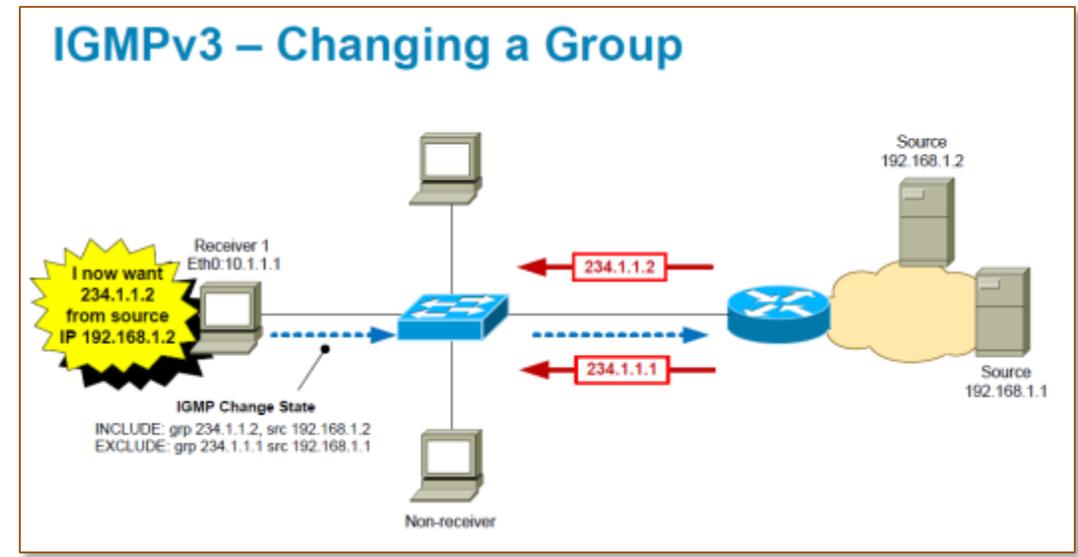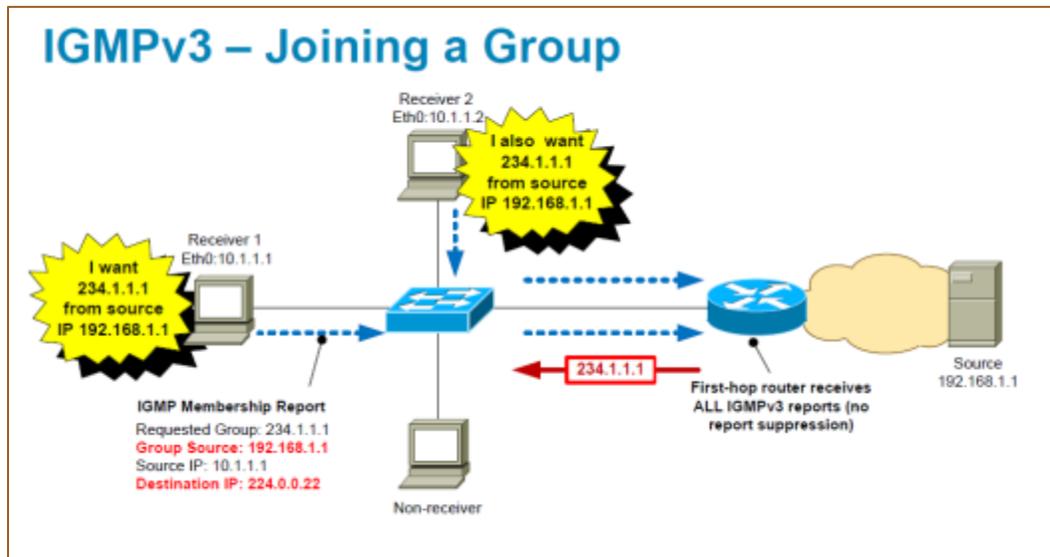
These diagrams are quoted from https://mrncciew.com/2012/12/25/igmp-basics/

OSPF (Open Shortest Path First)

- https://en.wikipedia.org/wiki/Open_Shortest_Path_First
  - It is one of routing protocols for IP networks
  - It gathers link state information from available routers and constructs a topology map of the network
- You don't need to make a routing table manually, OSFP does automatically
  - But you have to consider how a routing table changes when one of switches accidentally stops
- Use for Media Plane or Control Plane

192.168.100.253

192.168.110.253

192.168.120.253

VLAN110

VLAN120

VLAN130

Media Node
192.168.130.2/24

VLAN100

192.168.110.254

192.168.120.254

192.168.130.254

OSPF

192.168.130.0/24
→ 192.168.110.253

192.168.130.0/24
→ 192.168.120.253

192.168.130.0/24
→ 192.168.130.254

OSPF

OSPF

Xcelux
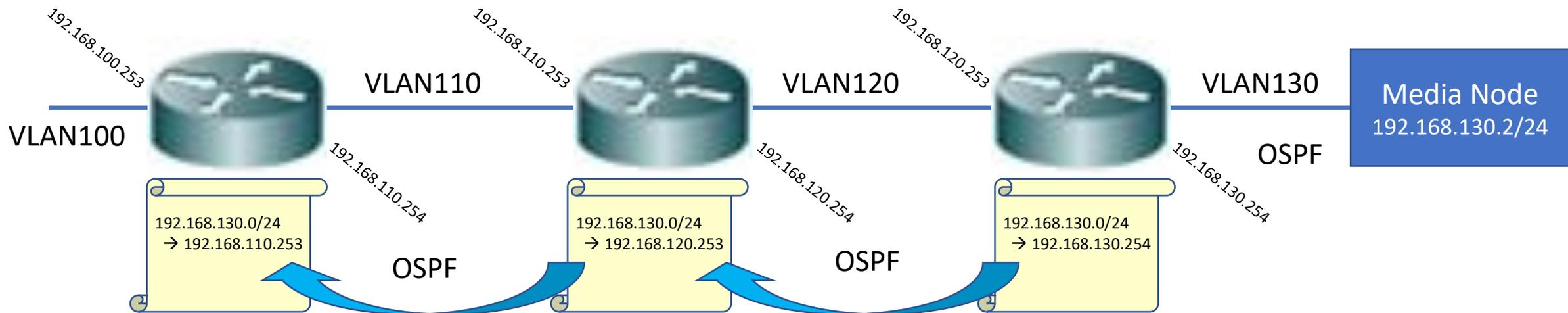
LAG (Link Aggregation Group) / LACP (Link Aggregation Control Protocol)

- https://en.wikipedia.org/wiki/Link_aggregation
  - It is the combining (aggregating) of multiple network connections in parallel by any of several methods
  - Implementation for Ethernet = LACP
    1. Maximum number of bundled ports allowed in the port channel: Valid values are usually from 1 to 8.
    2. LACP packets are sent with multicast group MAC address 01:80:C2:00:00:02
    3. During LACP detection period
       - LACP packets are transmitted every second
       - Keep-alive mechanism for link member: (default: slow = 30s, fast=1s)
    4. Selectable load-balancing mode is available in some implementations
    5. LACP mode :
       - Active: Enables LACP unconditionally.
       - Passive: Enables LACP only when an LACP device is detected. (This is the default stateControl Plane

- MLAG: Multi-chassis Link Aggregation Group
  - https://en.wikipedia.org/wiki/Multi-chassis_link_aggregation_group
    - It is a type of LAG with constituent ports that terminate on separate chassis

- Use for Control Plane

This diagram is quoted from
https://docs.nvidia.com/networking/display/ONYXv381174/MLAG
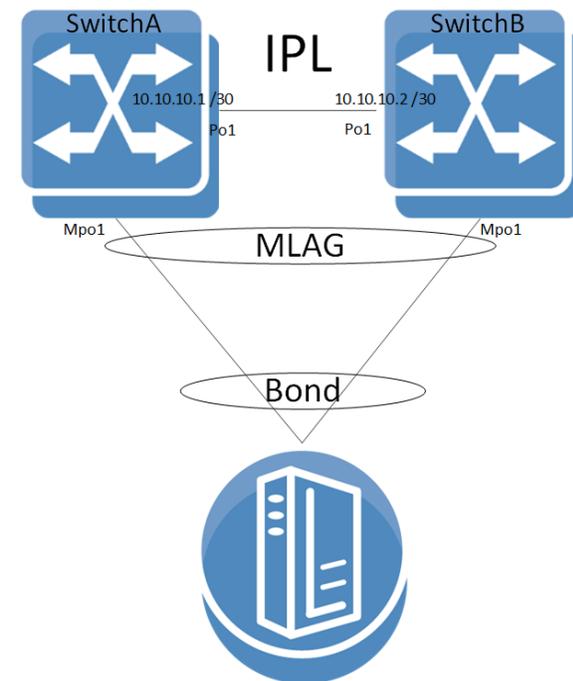
VRRP (Virtual Router Redundancy Protocol)

- **https://en.wikipedia.org/wiki/Virtual_Router_Redundancy_Protocol**
  - It provides for automatic assignment of available IP routers to participating hosts
 - Increase the availability and reliability of the network
- Use for Control Plane

This diagram is quoted from
https://www.globalknowledge.com/us-en/resources/resource-library/articles/hot-standby-router-protocol-vs-virtual-router-redundancy-protocol-what-s-the-difference/#gref

Conclusion
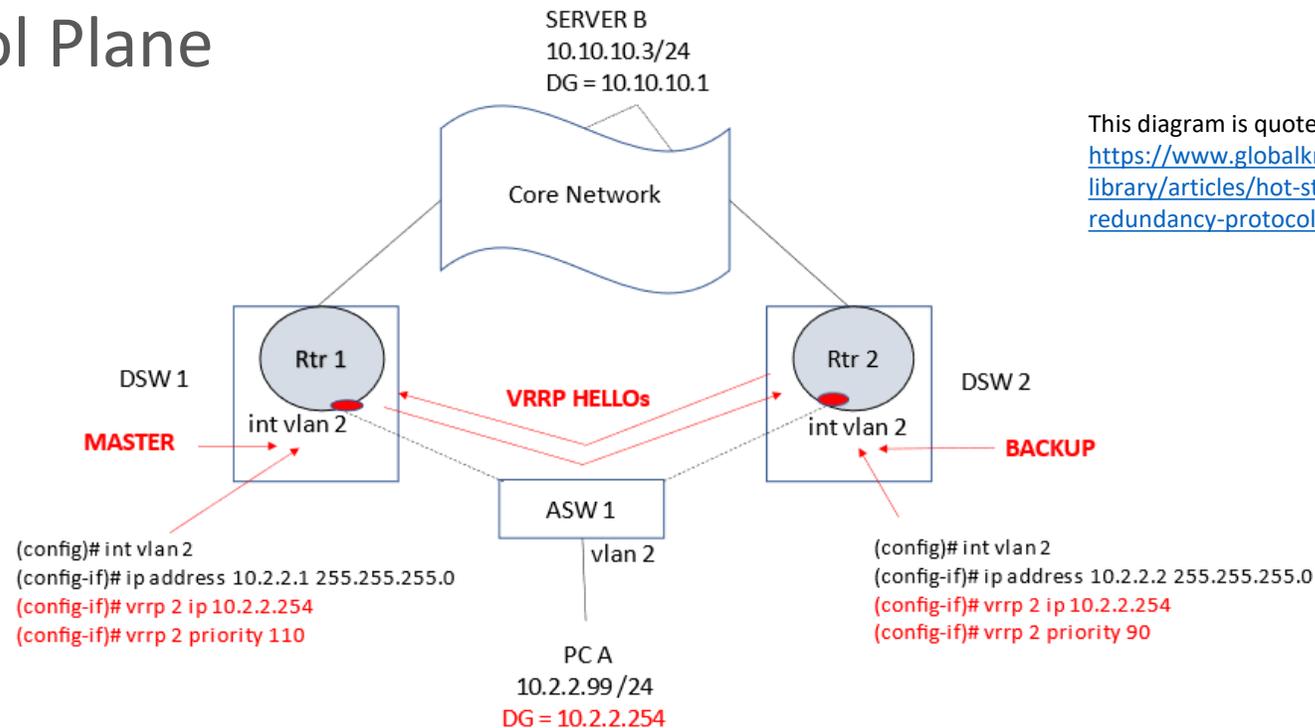
- How many key words did you know?

- SDN controller can configure NW switches
  - But, if you don't know these fundamental technologies, you never analyze any issues when your system don't work what you expect

- Next step: Hopefully in IBC this September
  - Design Cases
  - Verification
  - Network Issues
  - Debugging   etc ...

Checklist
- ☑ VLAN
- ☑ VRF
- ☐ Multicast routing
  - ☐ PIM
  - ☐ IGMP
- ☐ OSPF
- ☐ LAG/LACP
- ☐ VRRP

Questions

- Feel free to email me ☺
  - koji@xceluxdesign.com

- If you would like to communicate other network engineers for a MoIP design, I will invite you to the slack channel "MoIP Square"
  - Objective:
    - help each others
      - free, no obligations, volunteer-based, respect each others, use English only please
      - exchange information, ask a question, ask a help, advise someone according to your experience
  - You need to be a slack paid user because it is a slack connect channel
    - https://slack.com/resources/using-slack/getting-started-with-slack-connect

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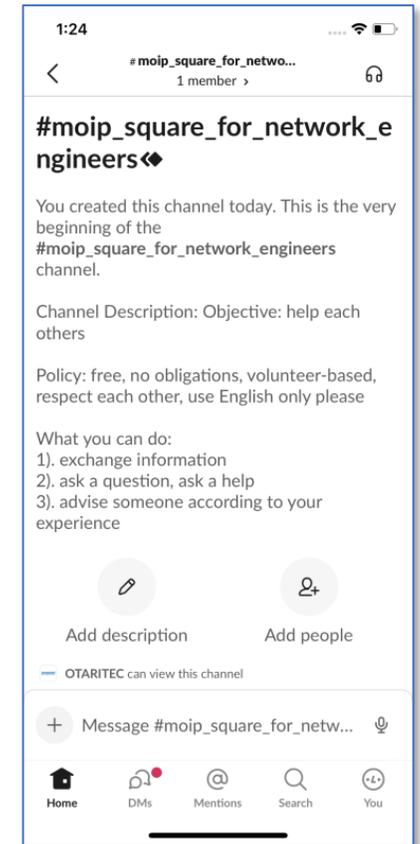
Thank You!

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