Essentials for Media-over-IP Network Design

Koji Oyama, Xcelux Design Inc.

koji@xceluxdesign.com

IP SHOWCASE

Audio Engineering Society · AIMS Alliance for IP Media Solutions · AMWA Networked Media. Working. · EBU · SMPTE · VSF Video Services Forum

Agenda

- Introduction
- Media-over-IP (MoIP) Network Design
- Essential Technologies
- Conclusion

Introduction

- Koji Oyama 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

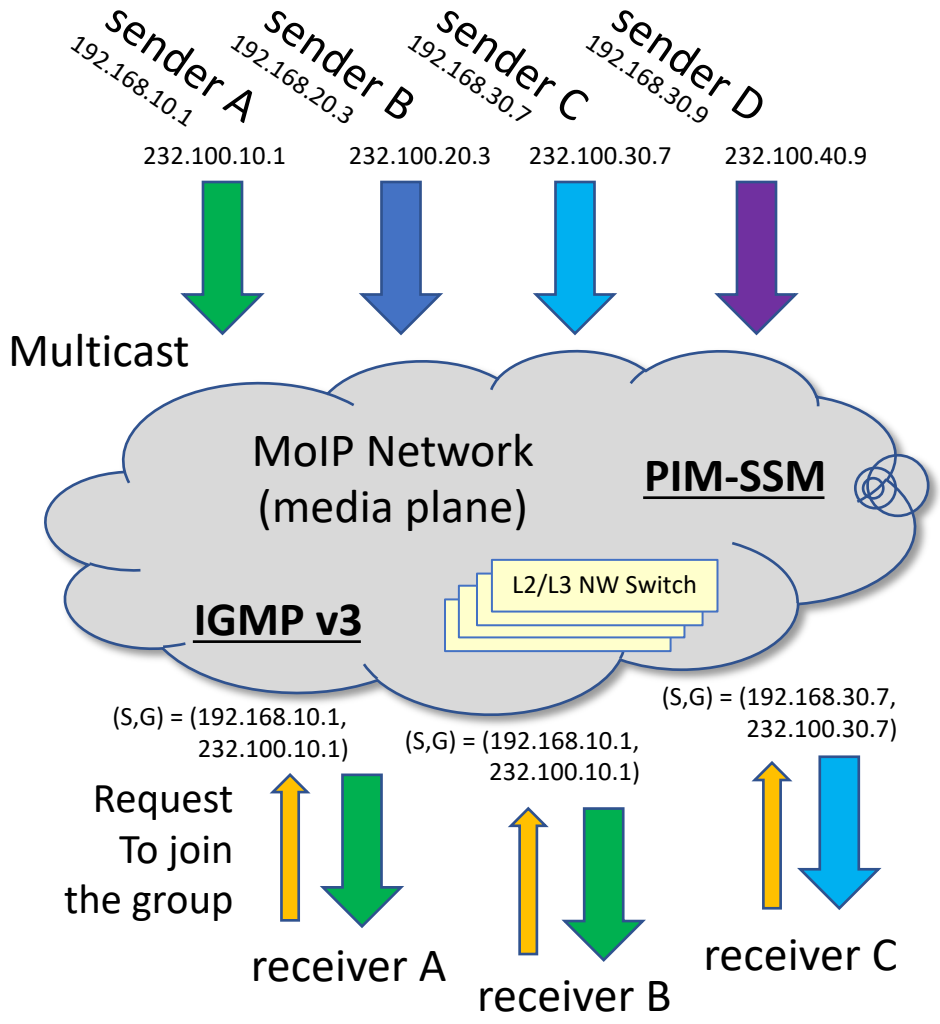
OSI model

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

Media over IP (1)

- 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

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	192.168.21.200	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.

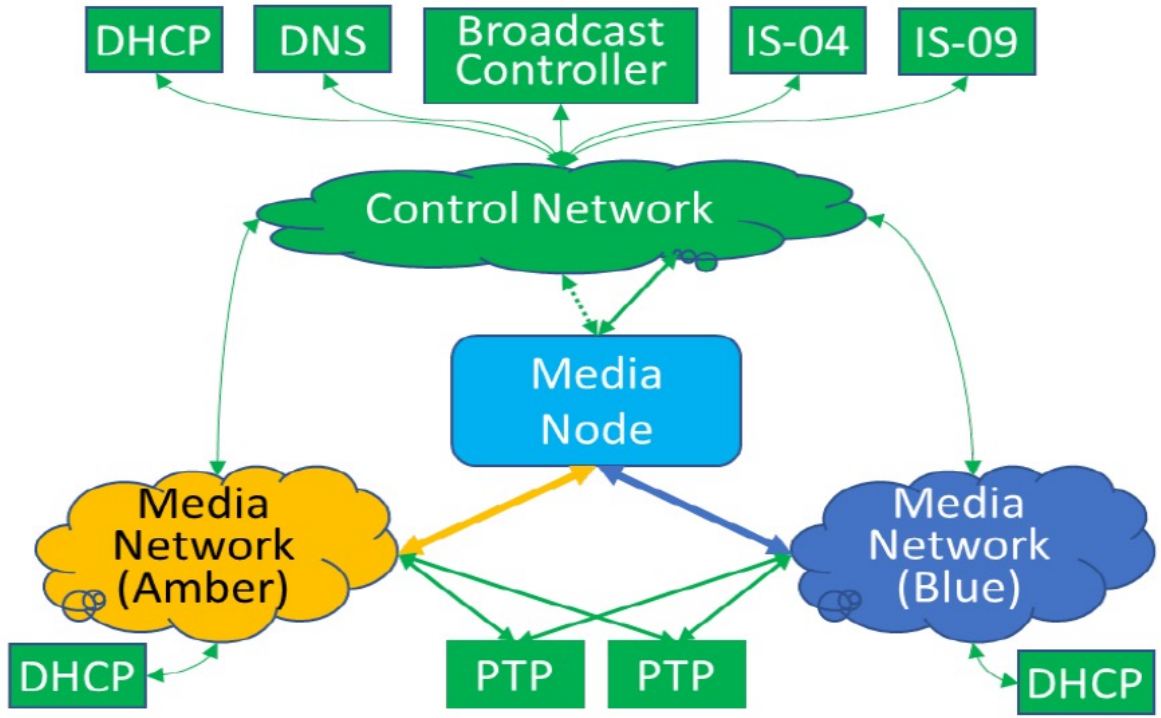
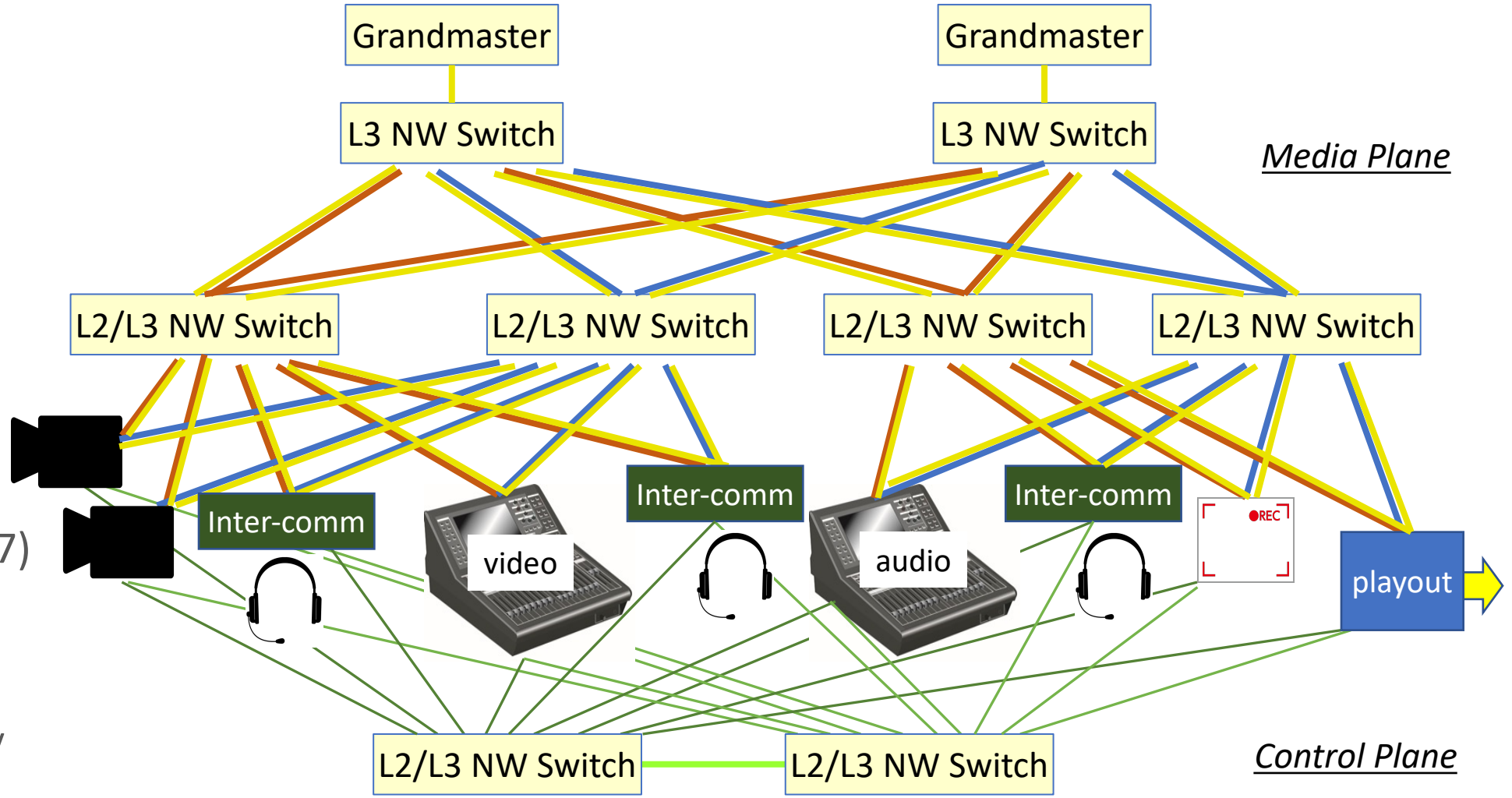


Figure 1 – Abstract Network Environment Diagram

MoIP Network Example

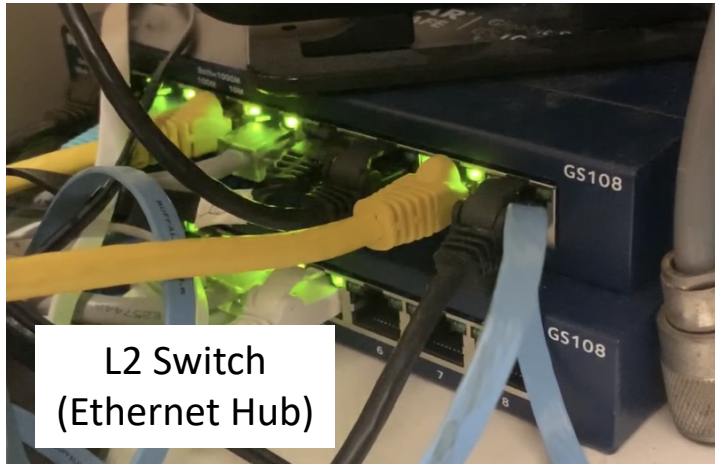
- Production for Video, Audio, Inter-comm
- Spine-Leaf NW switches
  - Non-blocking
- ST 2059 PTP
  - Boundary clock
  - BMCA
- Redundant (ST 2022-7)
- Separated media and control plane
  - Logically / Physically



Network L2/L3 Switches

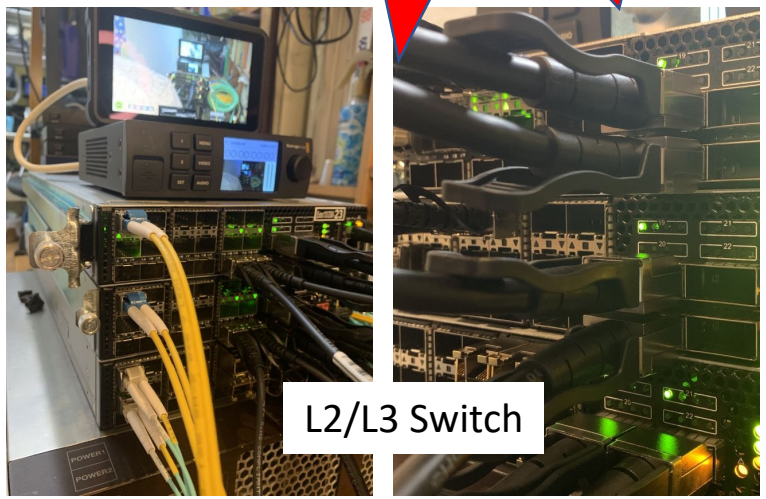
- More functionality: L2 ⇔ L3/L2
- High performance: Non-blocking
- Configurable: Unmanaged ⇔ Managed
- Resource Sharable: VLAN, VRF
- Redundant Power
- Speed: GbE ⇔ GbE, 10GbE, 25GbE, 40GbE, 100GbE
- Cable: CAT5e/6 Copper Cable ⇔ Optical Cable

Needs to be CONFIGURED more



L2 Switch (Ethernet Hub)

Home Use

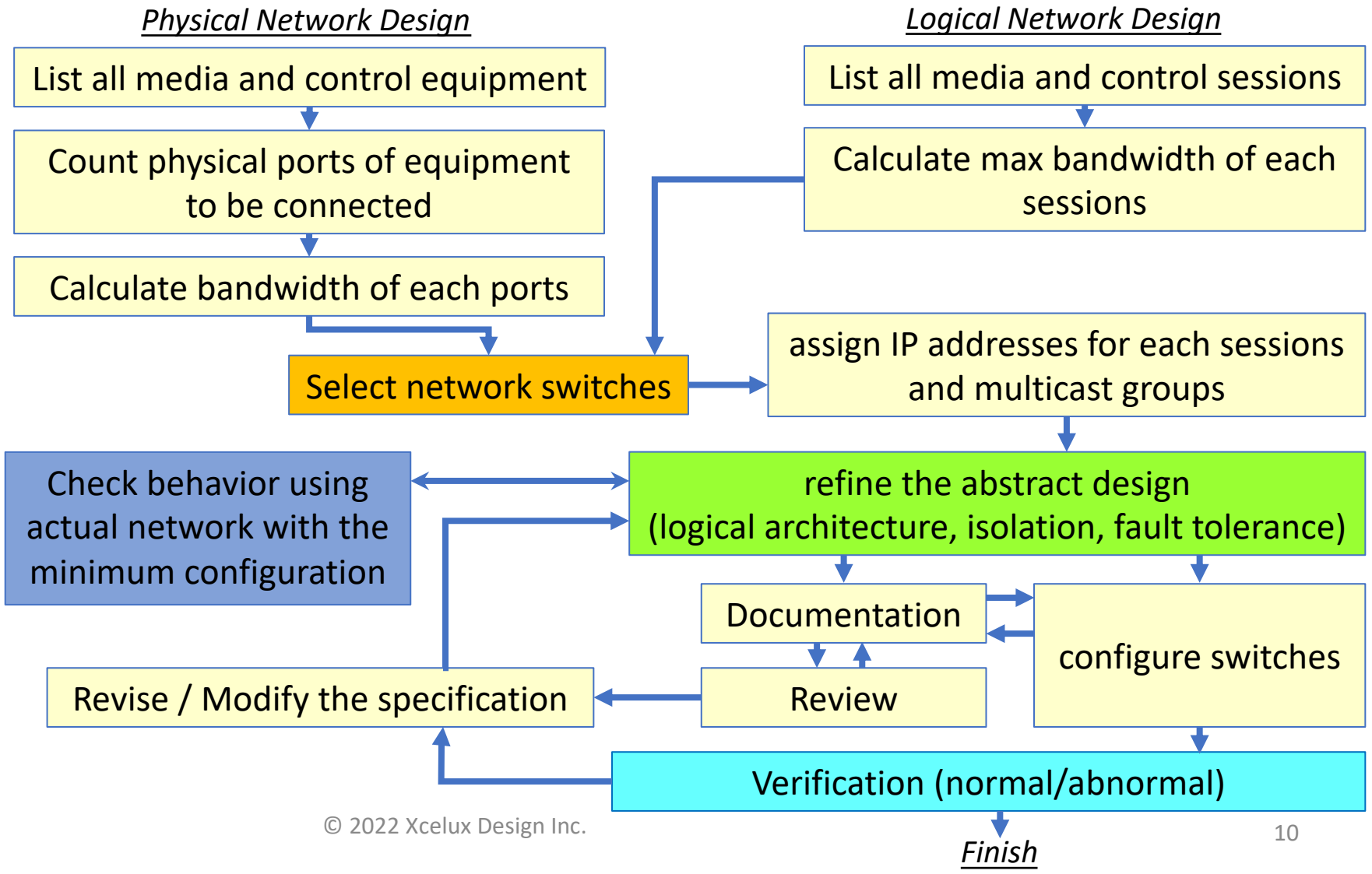


L2/L3 Switch

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.



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: 888bd2e4dce17e44xxxxxxxxxxxx
# 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
```

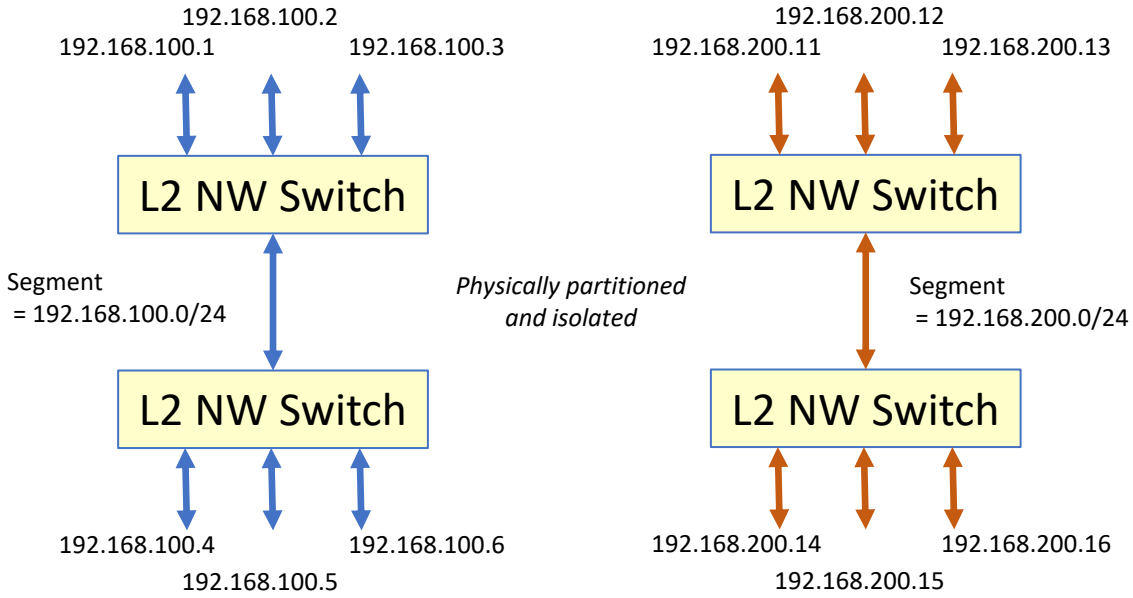
```
##
## Interface Ethernet configuration
##
   interface ethernet 1/1 speed 10G force
   interface ethernet 1/2 speed 10G force
   interface ethernet 1/1 switchport mode trunk
   interface ethernet 1/2 switchport mode trunk
   interface ethernet 1/19 switchport mode trunk
   interface ethernet 1/20 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
```

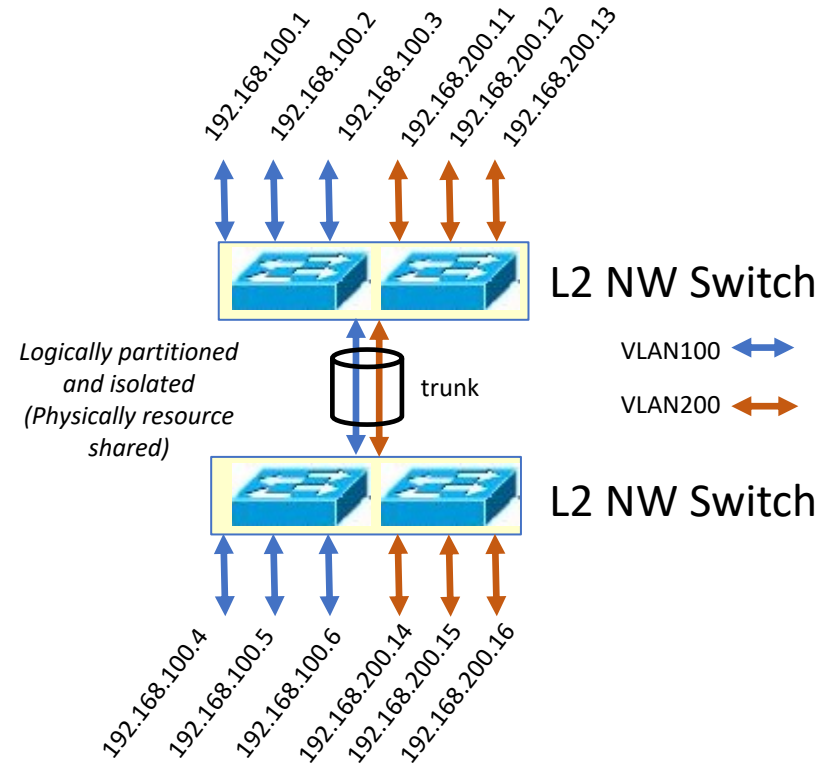
Essential Network Technologies

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

VLAN (Virtual Local Area Network)

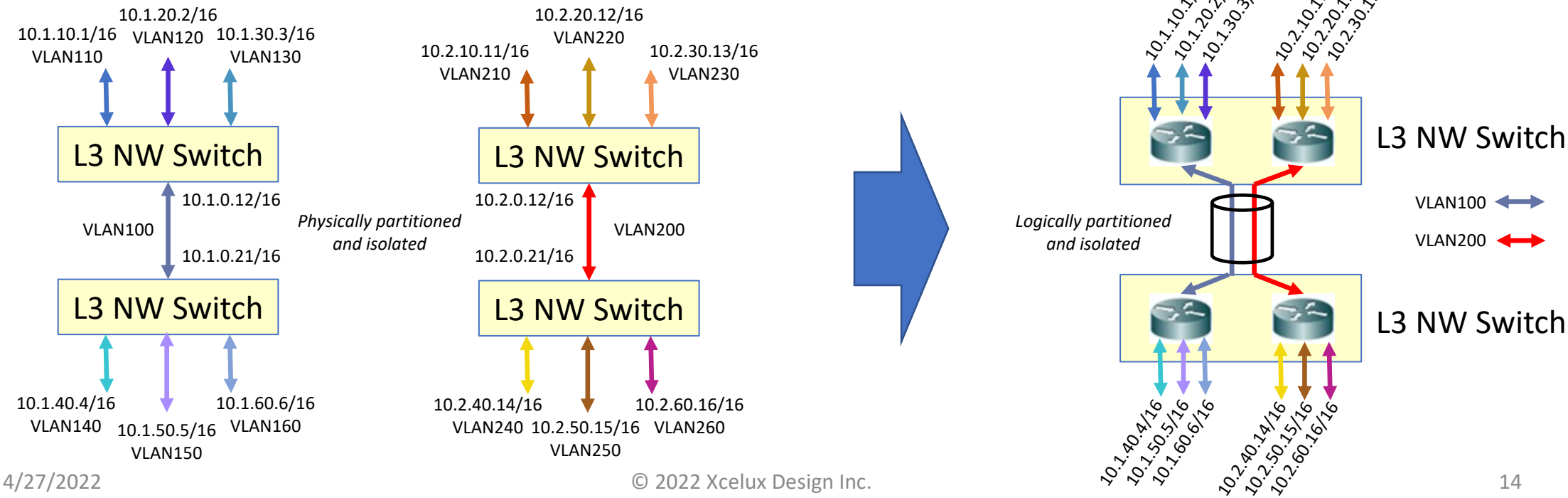
- https://en.wikipedia.org/wiki/Virtual_LAN
  - It is a technology to set virtual groups of devices and operate each as if they were one LAN
  - It is any broadcast domain that is partitioned and isolated in a network
- Use for Media Plane or Control Plane, Layer 2
- Port VLAN, Tag VLAN (IEEE802.1Q)





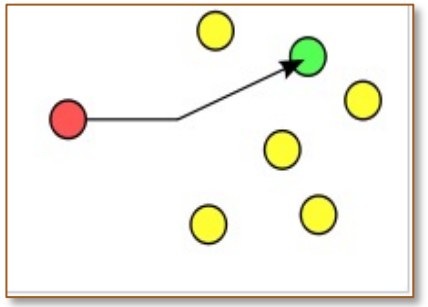
VRF (Virtual Routing and Forwarding)

- 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

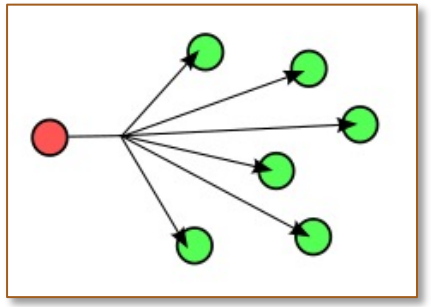


Multicast routing

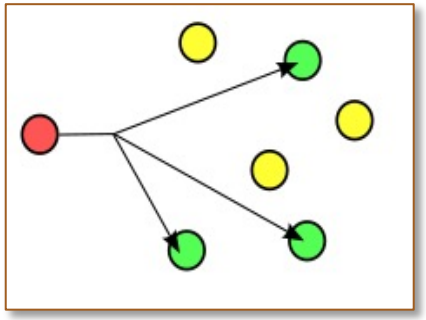
- https://en.wikipedia.org/wiki/Multicast_routing
  - a method of transmitting to all subscribers registered in a group by one transmission
- Use for Media Plane
- Multicast protocols: PIM, Multicast BGP, …



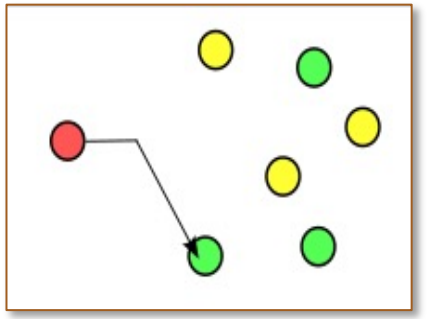
Unicast (one-to-one)



Broadcast (one-to-all)



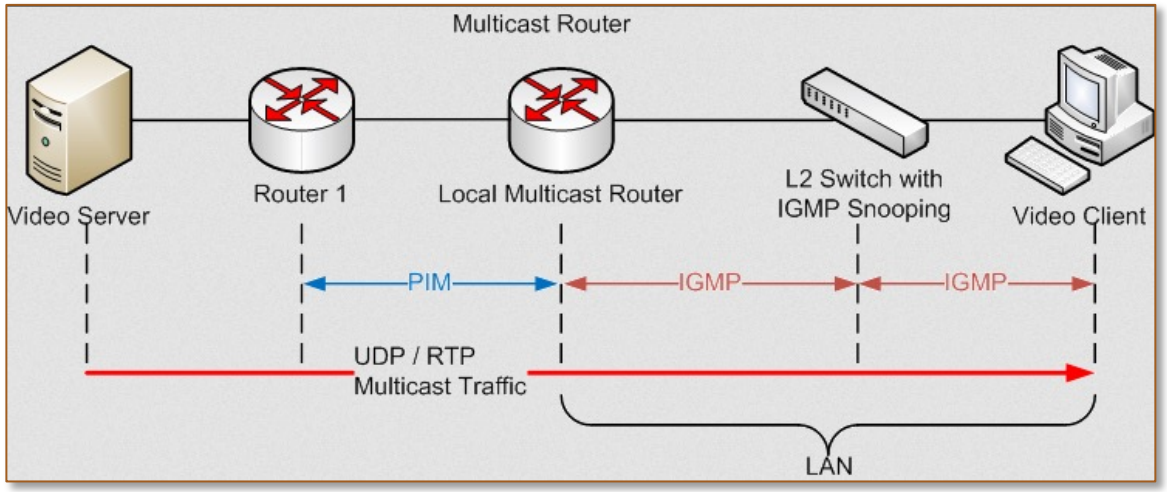
Multicast (one-to-many)



Anycast
(one-to-one-of-many)

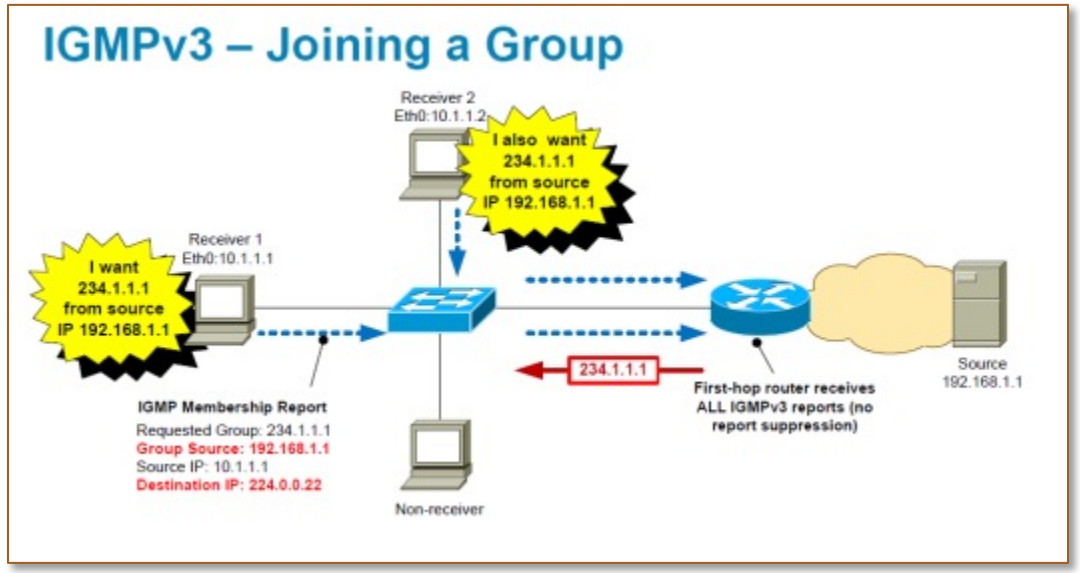
Multicast routing: PIM(Protocol Independent Multicast)

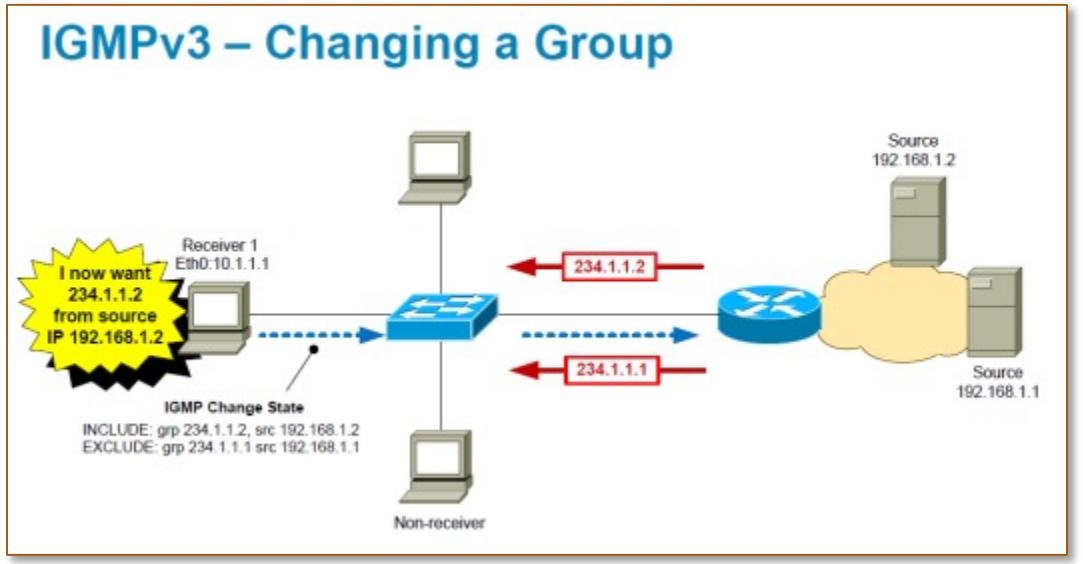
- https://en.wikipedia.org/wiki/Protocol_Independent_Multicast
  - One of multicast routing protocol
  - PIM does not include its own topology discovery mechanism → Protocol Independent
- Use for Media Plane
- 4 variants: PIM-SM, PIM-DM, Bidir-PIM, PIM-SSM



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

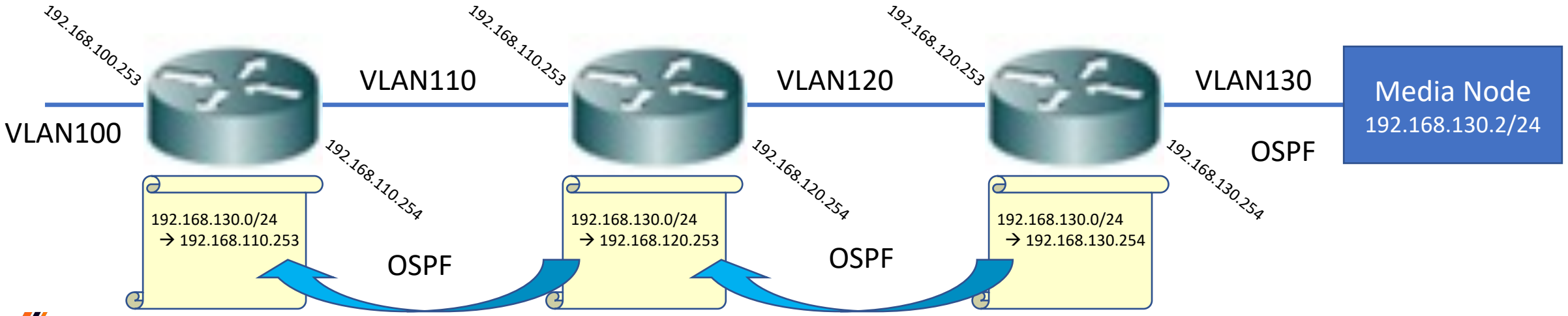




These diagrams are quoted from https://mrncciew.com/2012/12/25/igmp-basics/

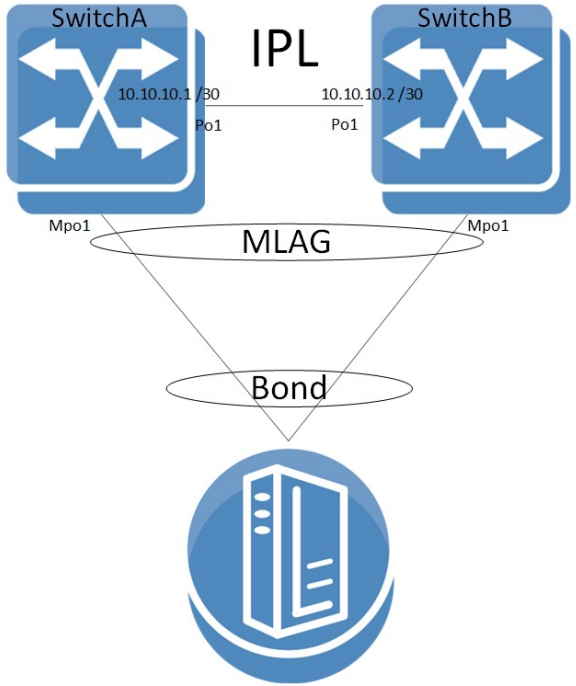
OSPF (Open Shortest Path First)

- 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



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

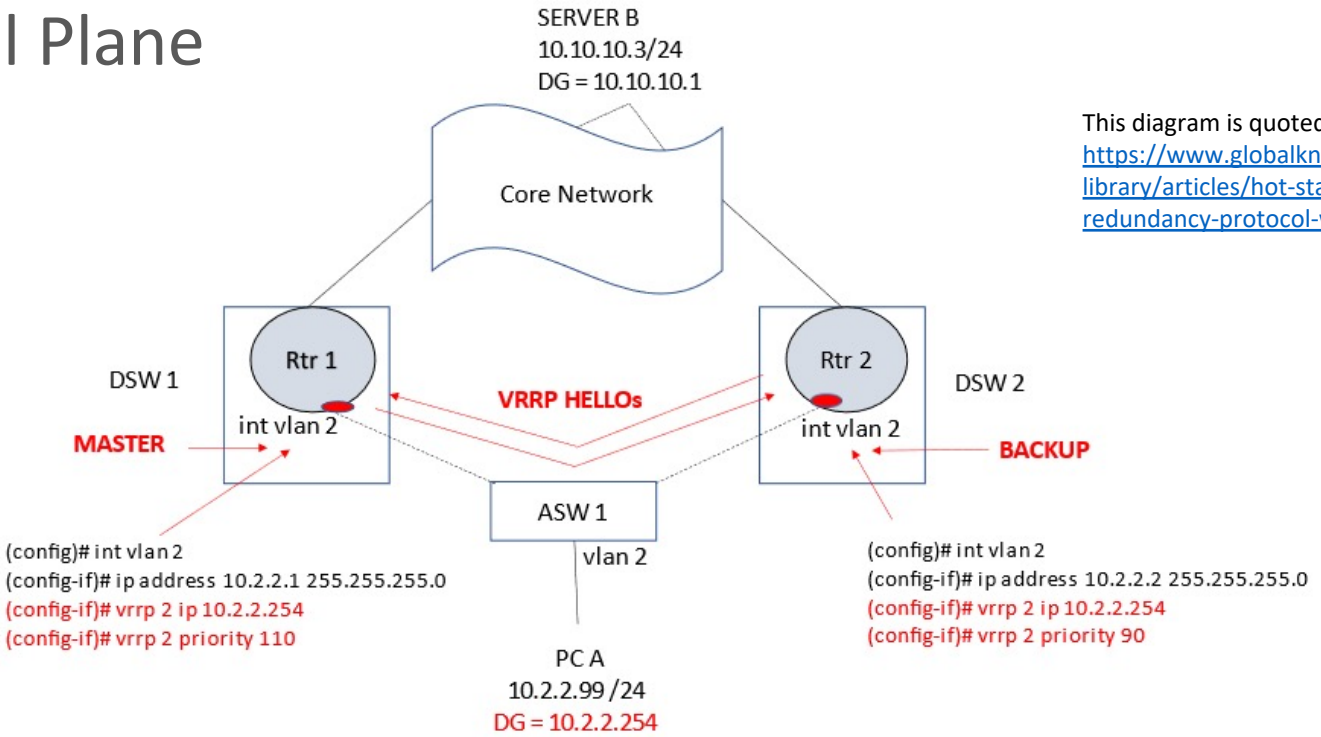
- https://en.wikipedia.org/wiki/Link_aggregation
  - It is the combining (aggregating) of multiple network connections in parallel by any of several methods
  - Implementation for Ethernet = LACP
    1. Maximum number of bundled ports allowed in the port channel: Valid values are usually from 1 to 8.
    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)

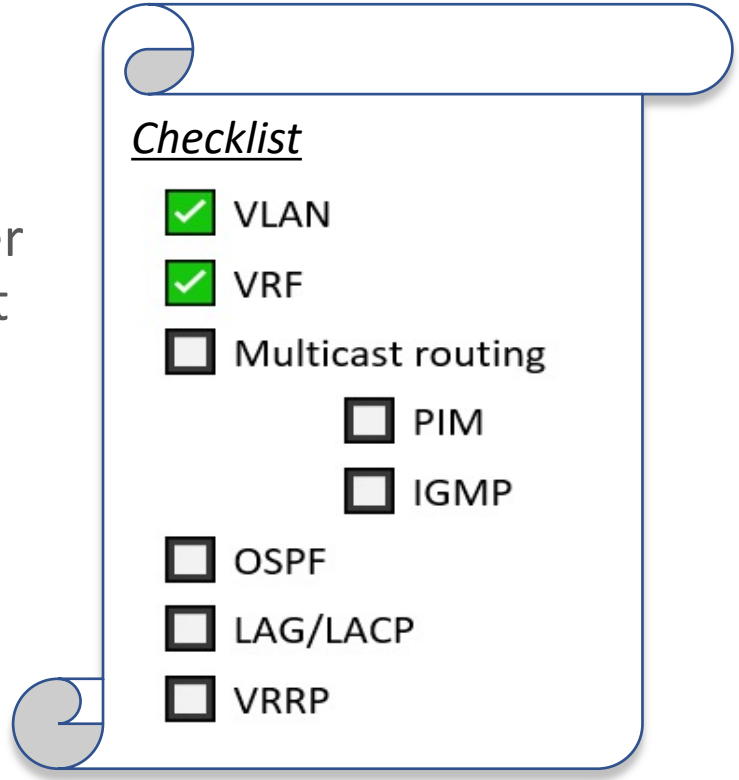
- https://en.wikipedia.org/wiki/Virtual_Router_Redundancy_Protocol
  - It provides for automatic assignment of available IP routers to participating hosts
  - Increase the availability and reliability of the network
- Use for Control Plane



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

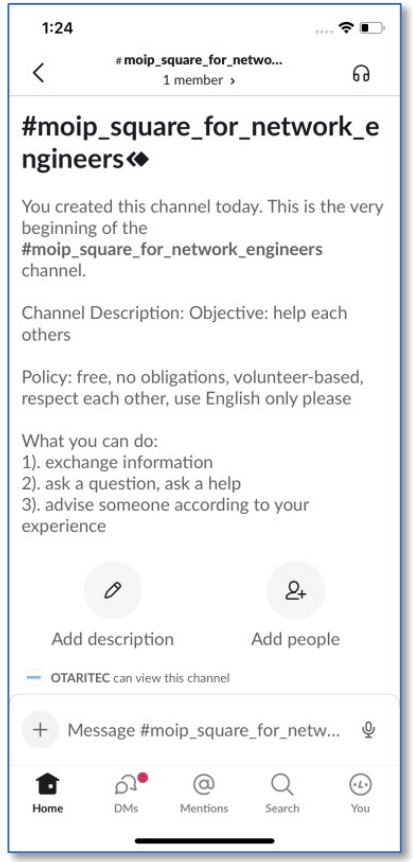
- How many key words did you know?
- SDN controller can configure NW switches
  - But, if you don't know these fundamental technologies, you never analyze any issues when your system don't work what you expect
- Next step: Hopefully in IBC this September
  - Design Cases
  - Verification
  - Network Issues
  - Debugging etc …



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



Thank You!

Koji Oyama, Xcelux Design Inc.

koji@xceluxdesign.com +81-90-1127-2023 / (408) 714-8808

IP SHOWCASE

Audio Engineering Society AIMS Alliance for IP Media Solutions AMWA Networked Media. Working. EBU SMPTE VSF Video Services Forum