Agenda

- IGP use cases and trends
- BGP use cases and trends
- Multicast routing use cases and trends
- MPLS use cases and trends

Routing the Cable Network

- What makes an architecture Cable?
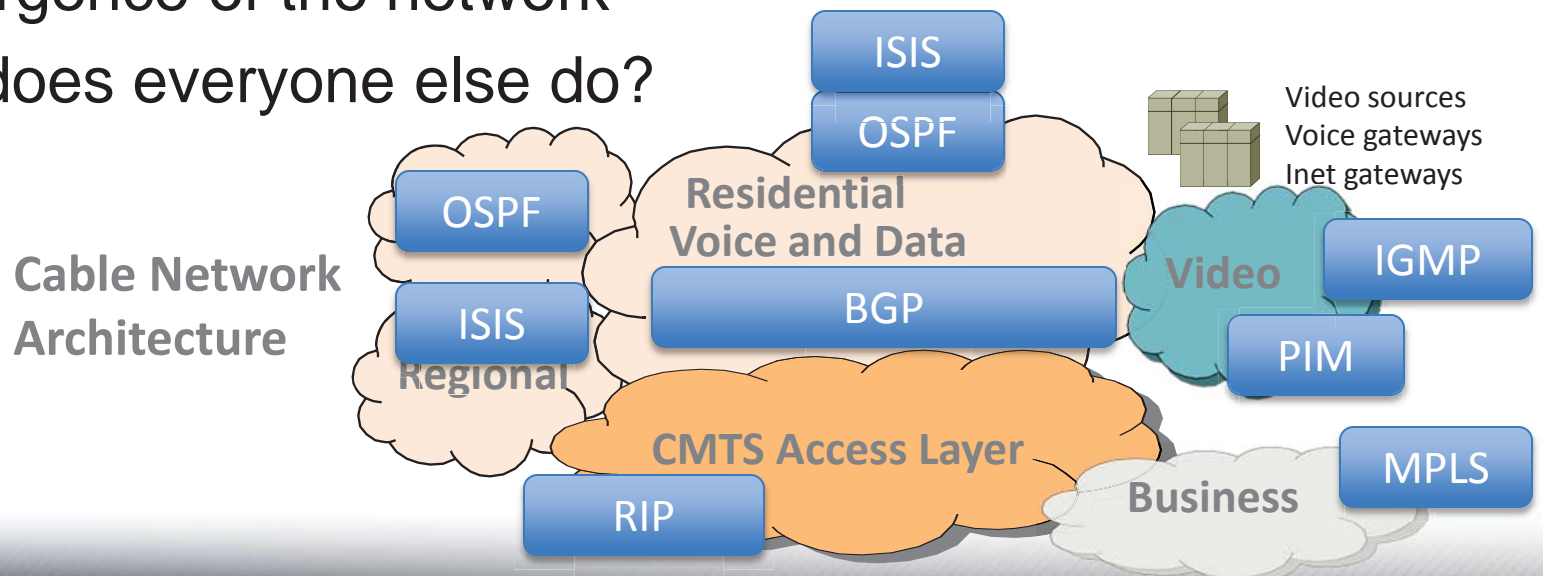 - CMTS access layer
  - Services
- North of the CMTS networks may resemble any service provider network. Operators must deal with everything.
- Among cable operators, Birds of a feather flock together. Trends get set. Uniqueness is limited.

Cable Network Architecture

Network North of Access Layer

CMTS Access Layer

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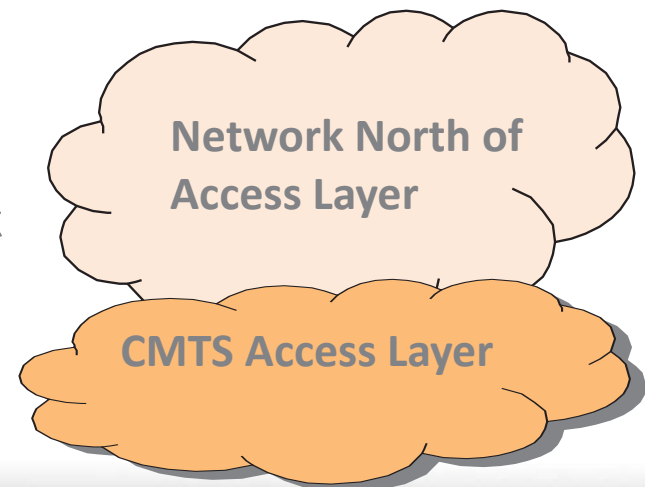
Routing the Cable Network

- What Routing protocols are needed/used
  - Depends on the service
    - Voice (High priority)
    - Data (Unicast)
    - Video (High use of multicast)
    - Commercial Business (VPNs)
- Convergence of the network
- What does everyone else do?

Cable Network Architecture

ISIS
OSPF

OSPF

ISIS

Regional

BGP

Residential Voice and Data

CMTS Access Layer

RIP

Video

Video sources
Voice gateways
Inet gateways

IGMP

PIM

Business

MPLS

Routing in Cable - IGP

- OSPF and ISIS are used to
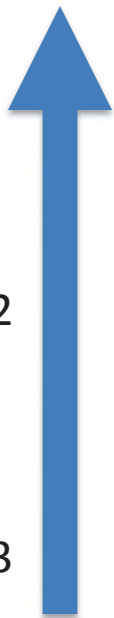 - Distribute infrastructure reachability within an AS
  - Enablement of BGP i.e. next hop reachability
  - Source reachability for multicast routing
- Customer routes within an IGP will depend on how BGP is utilized.

MSO Autonomous System

BGP

Redistribution

Default Route

IGP

CMTS Edge

Routing Trends – Illustration

Increasing
Sub Count*

Tier 1

Tier 2

Tier 3

MSO #1
MSO #2
MSO #3
MSO #4
MSO #5
MSO #6
MSO #7
MSO #8
MSO #9
MSO #10
MSO #11
MSO #12

*MSO listed in random order within each tier.

Y	N
X	
	-

Future Migration

BGP

-Yes or No
-Specifics of a protocol i.e. type or version

Each MSO's answer is here
(X) Marks the answer
(-) Means not relevant
(◄••) likely to change to other answer

Protocol or feature

Routing Trends – Illustration

Increasing
Sub Count*

Tier 1

Tier 2

Tier 3

MSO #1
MSO #2
MSO #3
MSO #4
MSO #5
MSO #6
MSO #7
MSO #8
MSO #9
MSO #10
MSO #11
MSO #12

Y	N
X	
X	
	X
	X
	X
	X
	X

Red Represents **Minority**

Green Represents **Majority**

Yellow Represents **Balance**

BGP

MSO listed in random order within each tier.

Routing Trends - IGP

IPv4	IPv6		IPv4	IPv6
X				X
X				X
X				X
			X	X
X	X		X	
X	X			
X	-			-
X	X			
X				X
X				X
X	X			
X	-			-

OSPF	ISIS

Increasing Sub Count*
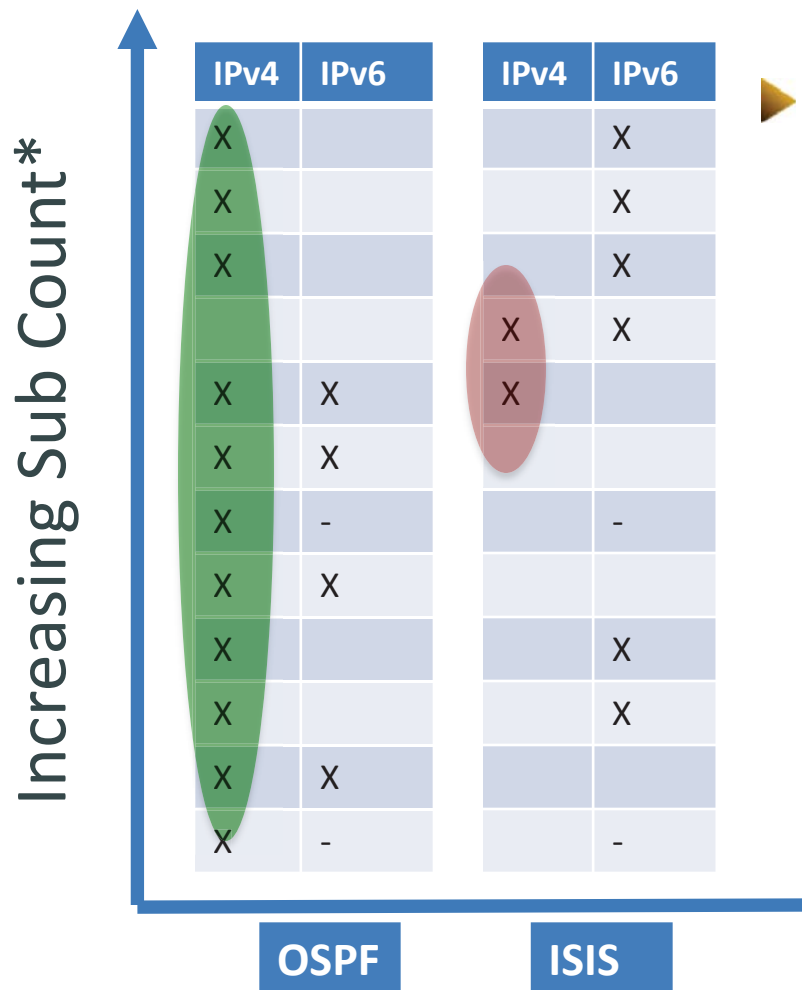
▶ More MSOs are using OSPF for IPv4

*MSO listed in random order from small to large

Routing Trends - IGP

Increasing Sub Count*

IPv4	IPv6
X	
X	
X	
X	X
X	X
X	-
X	X
X	
X	
X	X
X	-

OSPF

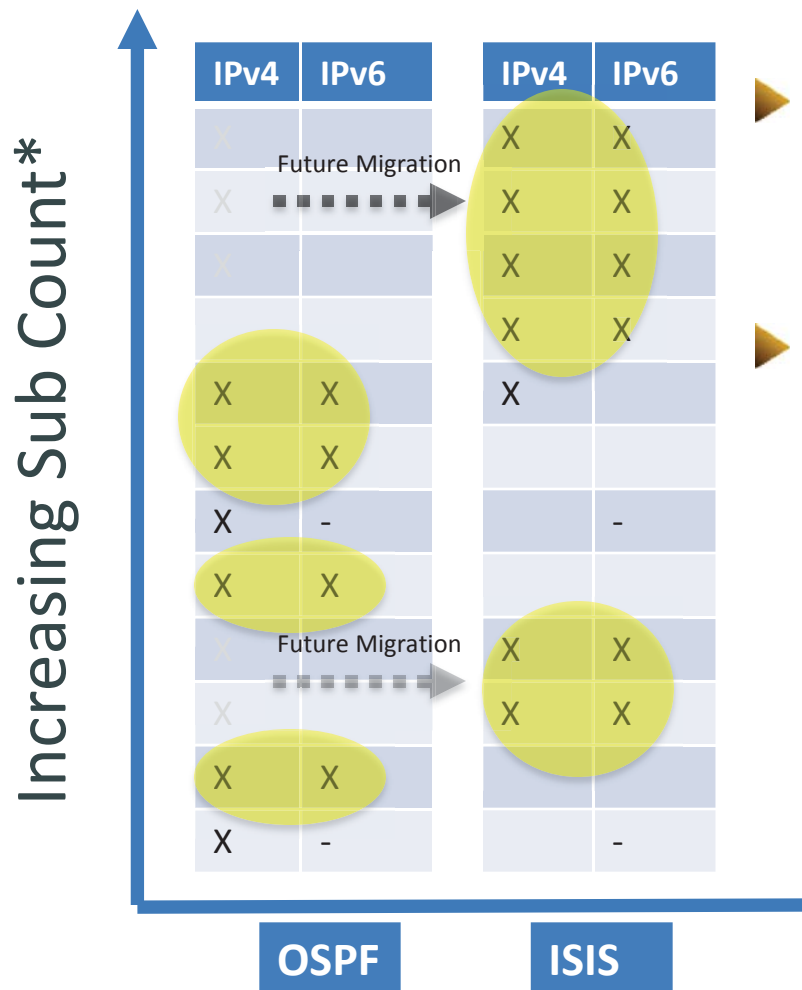| IPv4	IPv6
	X
	X
	X
X	X
X	
	-
	X
	X
	-
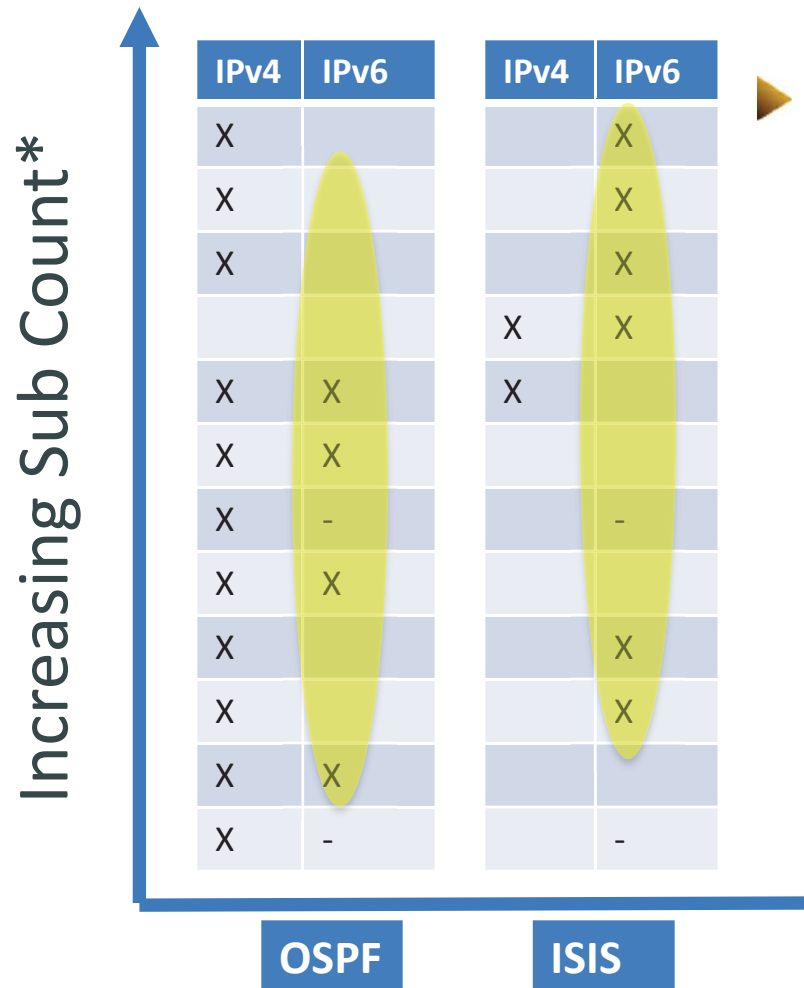
ISIS

▶ Balance between OSPF and ISIS for for v6

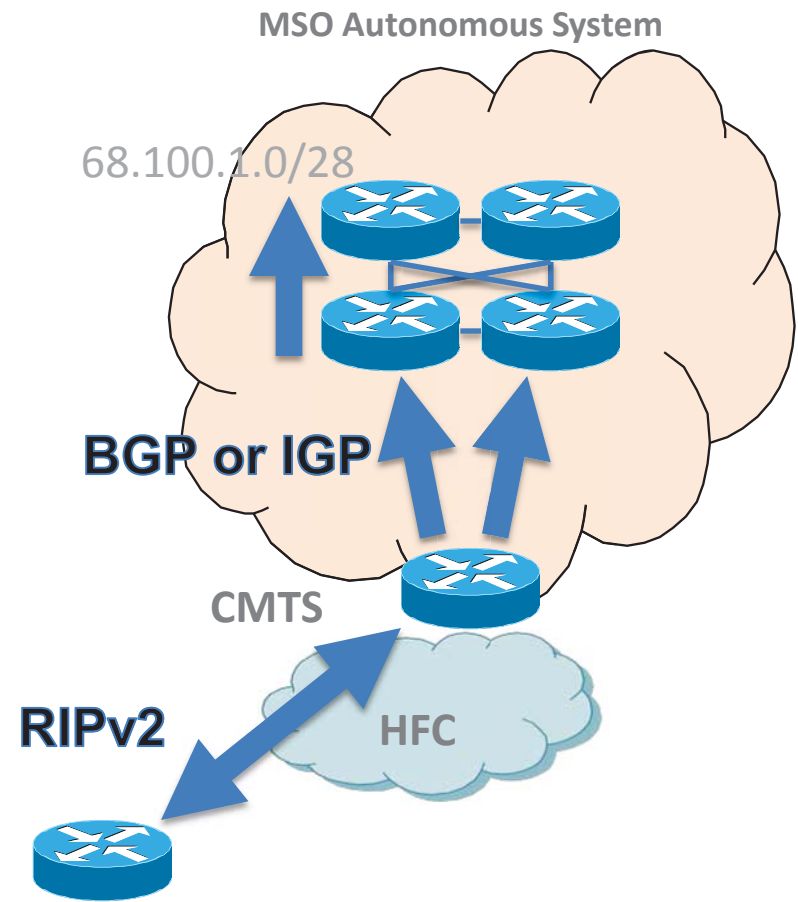*MSO listed in random order from small to large

Routing Trends - IGP

- Most MSOs have a plan to move or stay with one protocol for both v4 and v6.
- Once this transition is complete large MSOs will all be using ISIS for both IPv4 and IPv6

*MSO listed in random order from small to large

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Routing in Cable - IGP

- RIP is not utilized like OSPF or ISIS
- Dynamic mechanism to advertise customer subnets to CMTS
- Alternative is static routing on the CMTS redistributed into BGP or an IGP

MSO Autonomous System

68.100.1.0/28

BGP or IGP

CMTS

RIPv2

HFC

68.100.1.0/28

Routing Trends – IGP

Increasing Sub Count*

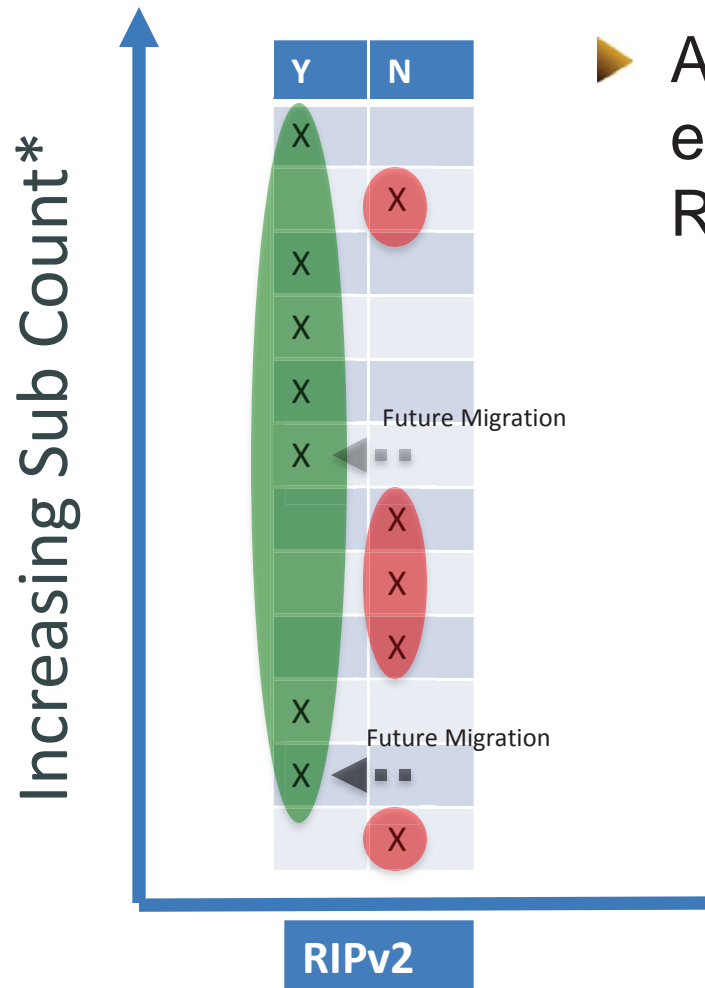| Y	N
X	
	X
X	
X	
X	
	X
	X
	X
	X
X	
	X
	X
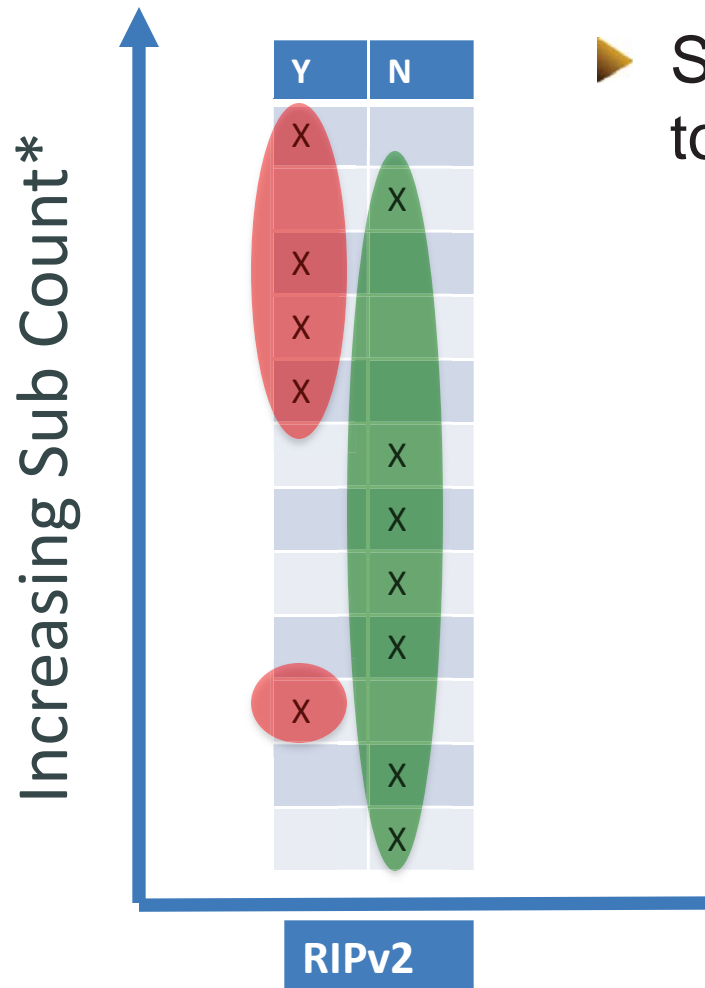
RIPv2

▶ Several large MSOs using RIP today

*MSO listed in random order from small to large

Routing Trends – IGP

Increasing Sub Count*

Y	N
X	
	X
X	
X	
X	
X	Future Migration ◀ ▪ ▪
	X
	X
	X
X	
X	Future Migration ◀ ▪ ▪
	X

RIPv2

▶ A few additional MSOs have expressed interest in using RIPv2
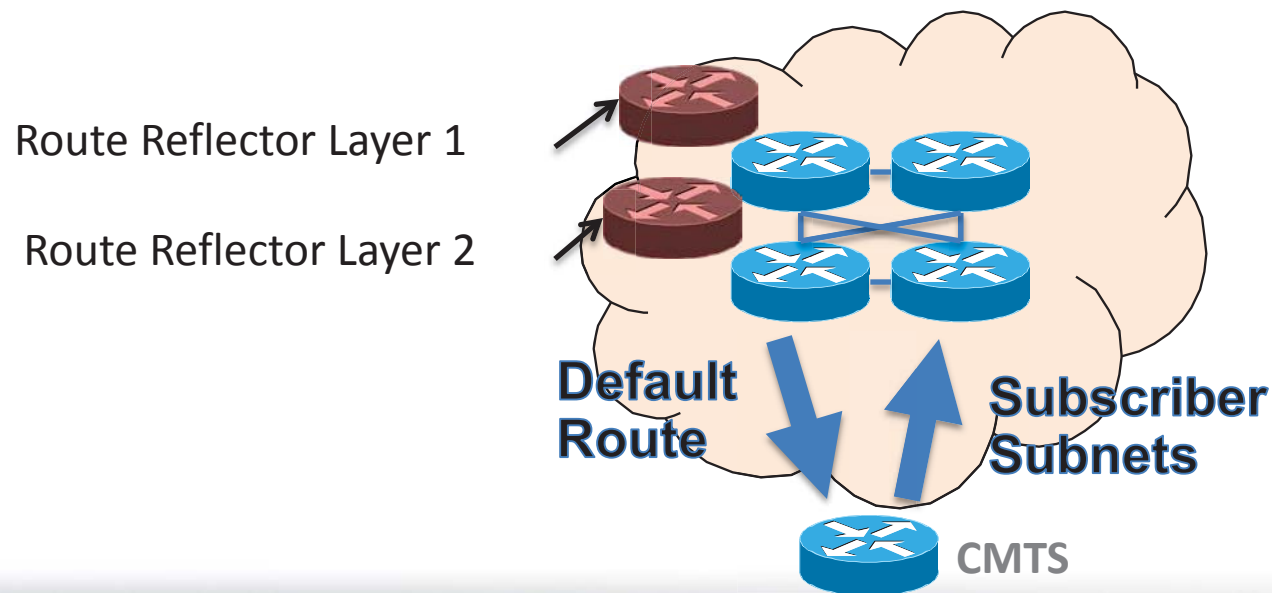
*MSO listed in random order from small to large

Routing in Cable - BGP

- BGP is the internet standard for advertisement and reachability of internet routes between Autonomous systems.
- All Cable operators run BGP
- How BGP is used will vary slightly across operators
  - BGP to the CMTS is a growing trend.
  - M-BGP used for VPNs, multicast and label distribution
  - Attribute manipulation
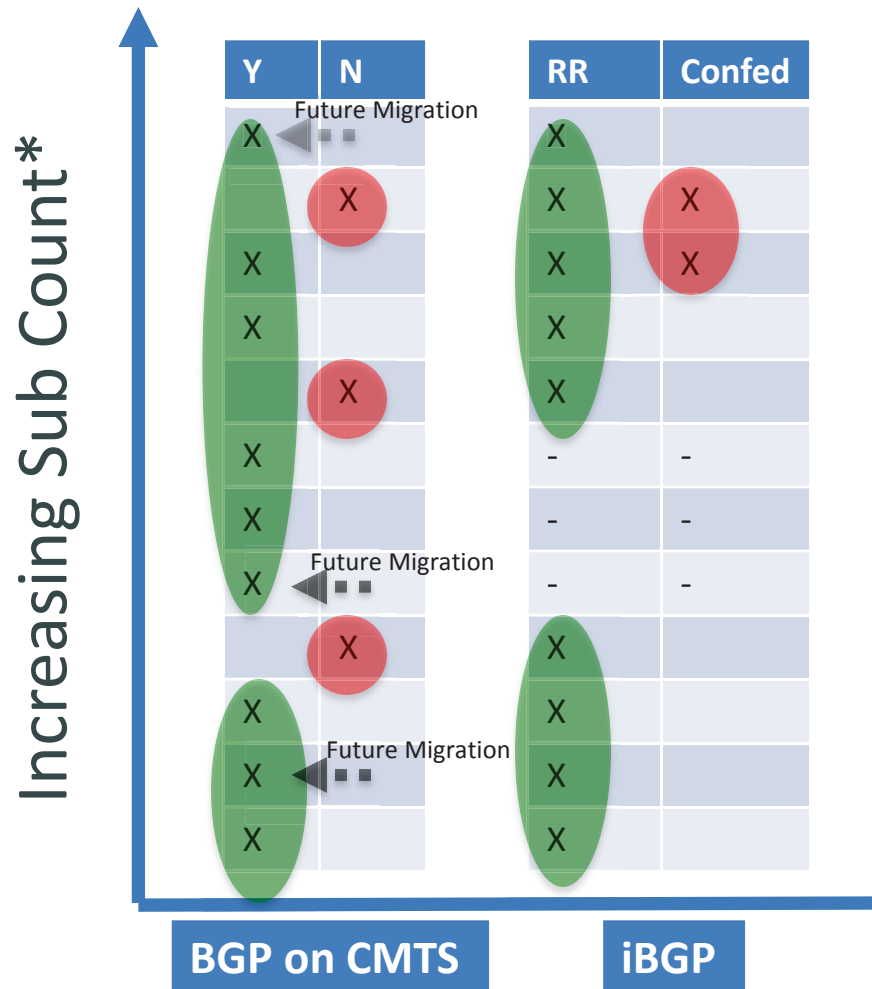
Routing in Cable - BGP

- Route Reflectors (RR) are a common practice to scale large BGP deployments and avoid the need for an iBGP full mesh.
- Sometimes more then one layer is utilized. ~2 to 3
- Although Confederations are also an option it is not as common in Cable.

MSO Autonomous System

Route Reflector Layer 1

Route Reflector Layer 2

Default Route

Subscriber Subnets

CMTS

Routing Trends – BGP

BGP on CMTS

Y	N
X	
	X
X	
X	
	X
X	
X	
X	
	X
X	
X	
X	

iBGP

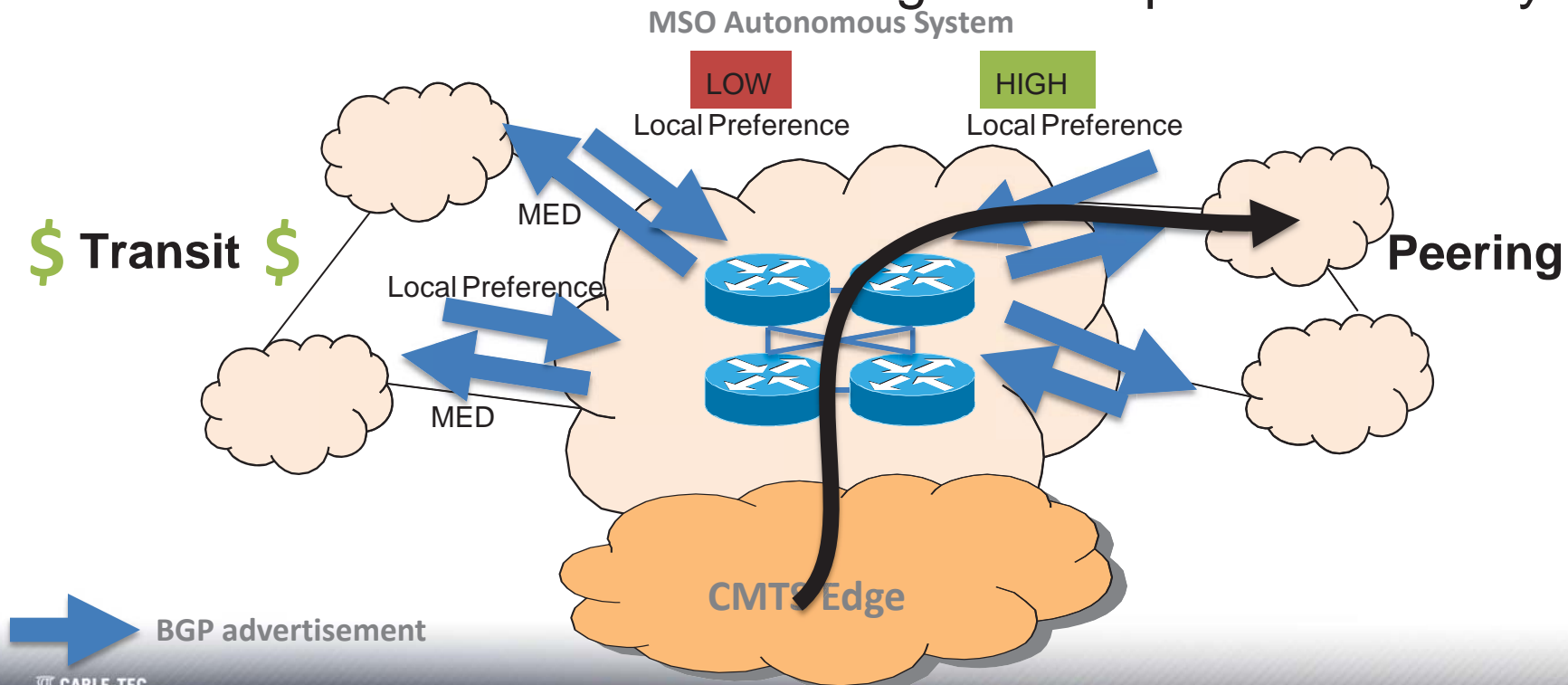| RR	Confed
X	
X	X
X	X
X	
X	
-	-
-	-
-	-
X	
X	
X	
X	

Increasing Sub Count*

Future Migration

- BGP to CMTS is a growing trend
- RR are more common then Confederations
- In some cases solving the iBGP full mesh is not required

*MSO listed in random order from small to large

Routing in Cable - BGP

- MSOs also pay Tier1 providers for **Transit** service. Transits are more likely to agree to terms e.g. honor MEDs

- **Peering** agreements are mutually beneficial to offload traffic from Transit links saving Cable operators money

MSO Autonomous System

LOW
Local Preference

HIGH
Local Preference

$ Transit $

MED

Local Preference

MED

Peering

CMTS Edge

BGP advertisement

Routing in Cable - MPBGP

- Most Common AFI/SAFI 1/1, 1/128

- Becoming Common   IPv6 AFI/SAFI 2/1, 2/4

- Some Cable operators are using BGP for more advanced video distribution mechanisms AFI/SAFI 1/2 , 1/4 ,1/5 , 1/129

AFI	
1	IPv4
2	IPv6

SAFI	
1	Unicast
2	Multicast Source reachability
4	MPLS label with NLRI
5	mVPN Auto Discovery and Cmulticast
128	VPN label
129	mVPN- Source reachability between PEs

Routing in Cable - Multicast

- Most common multicast protocols used in cable are PIM-SSM and IGMP

- IGMPv3 is preferred. Mapping or static methods are used to deal with legacy IGMPv2

- Most common use case for multicast in Cable networks is the distribution of broadcast video followed by DSG and VOD library content distribution

- IP multicast forwarding is more common than MPLS multicast forwarding in today's cable architectures
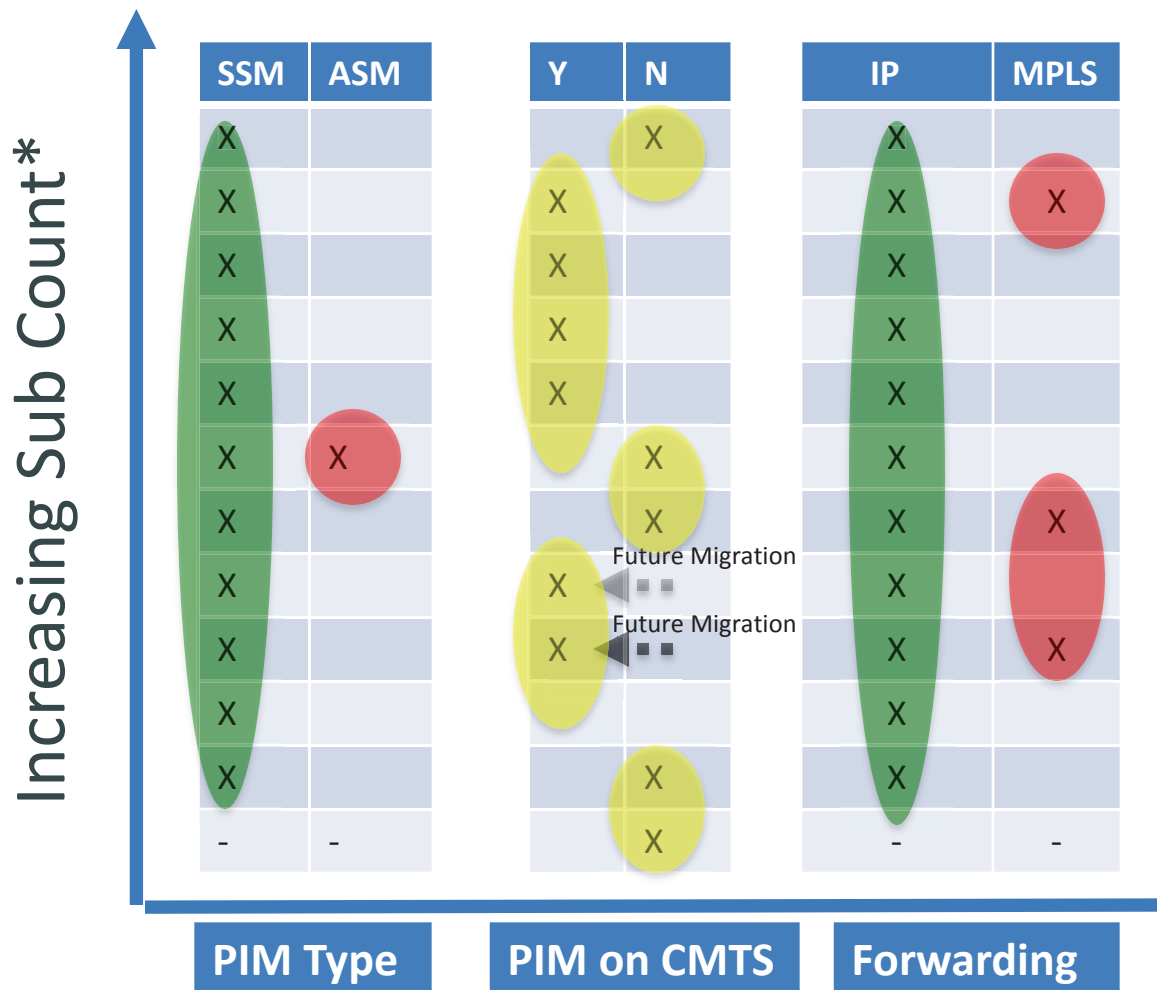
PIM-SSM + IGMPv3   PIM-ASM + IGMPv2

Routing Trends - Multicast
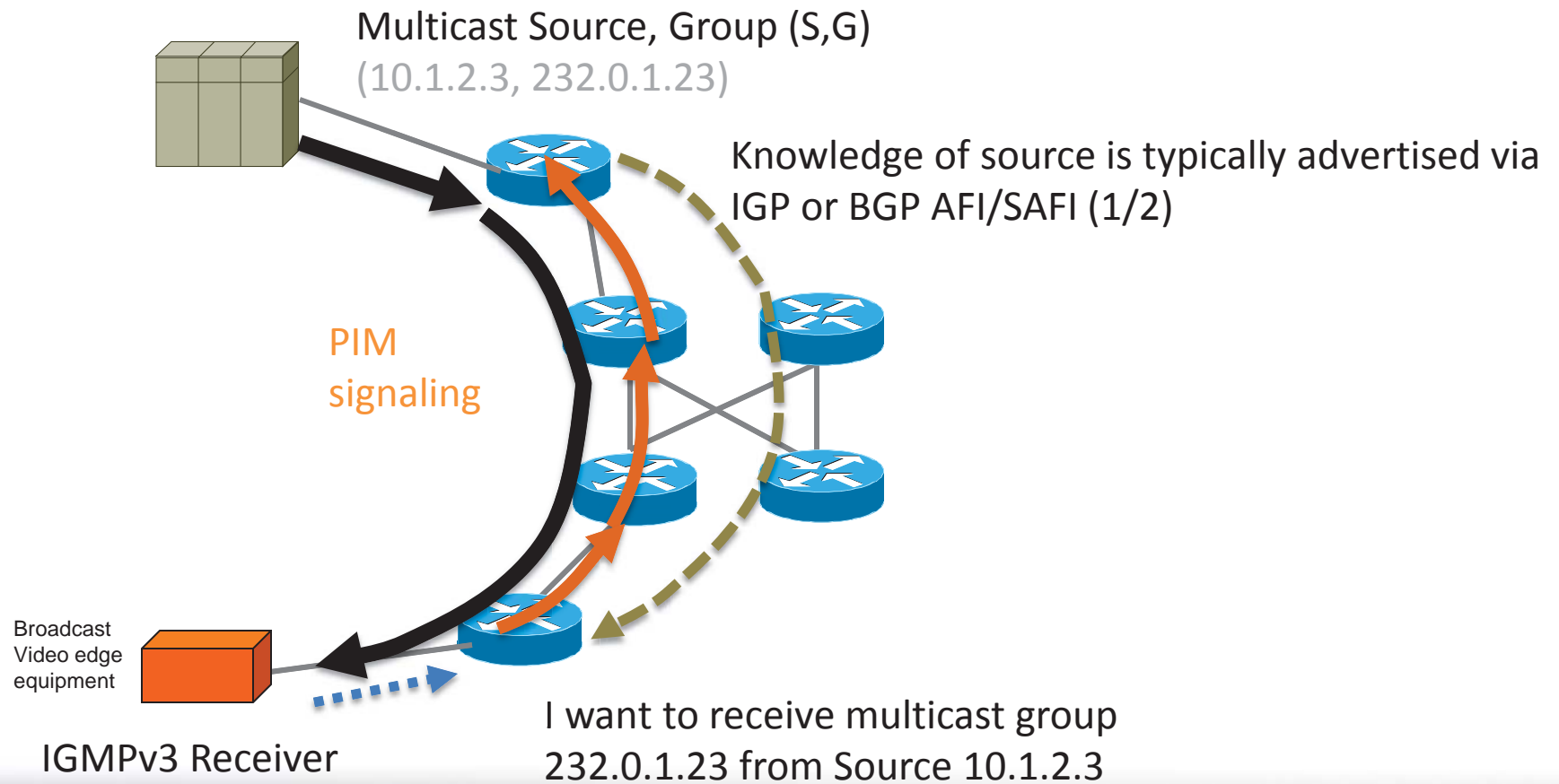

MSO listed in random order from small to large

- ▶ (SSM) Source Specific Multicast is the most common.
- ▶ Many large MSOs are running PIM on their CMTS.
- ▶ Mostly IP based multicast forwarding. Only a few using MPLS based forwarding.
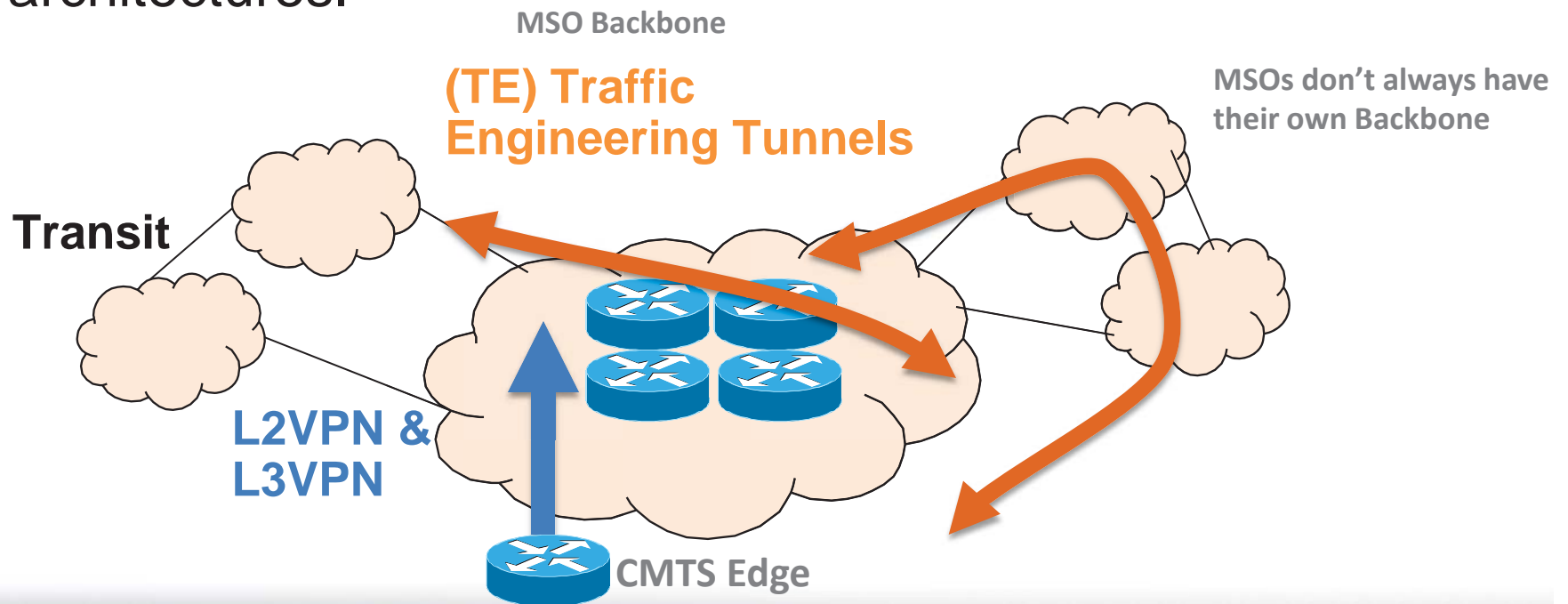
Routing in Cable – Multicast

- An example Multicast SSM architecture for Broadcast Video distribution

Multicast Source, Group (S,G)
(10.1.2.3, 232.0.1.23)

Knowledge of source is typically advertised via IGP or BGP AFI/SAFI (1/2)

PIM signaling

Broadcast Video edge equipment

IGMPv3 Receiver

I want to receive multicast group 232.0.1.23 from Source 10.1.2.3

Routing in Cable - MPLS

- MPLS or label based forwarding is primary used in cable to enable services
- L2VPNs and L3VPNs as well as traffic engineering are all current use cases of MPLS in today's cable architectures.

MSO Backbone

(TE) Traffic Engineering Tunnels

MSOs don't always have their own Backbone

Transit

L2VPN & L3VPN

CMTS Edge

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Telecommunications
Engineers

Routing in Cable - MPLS

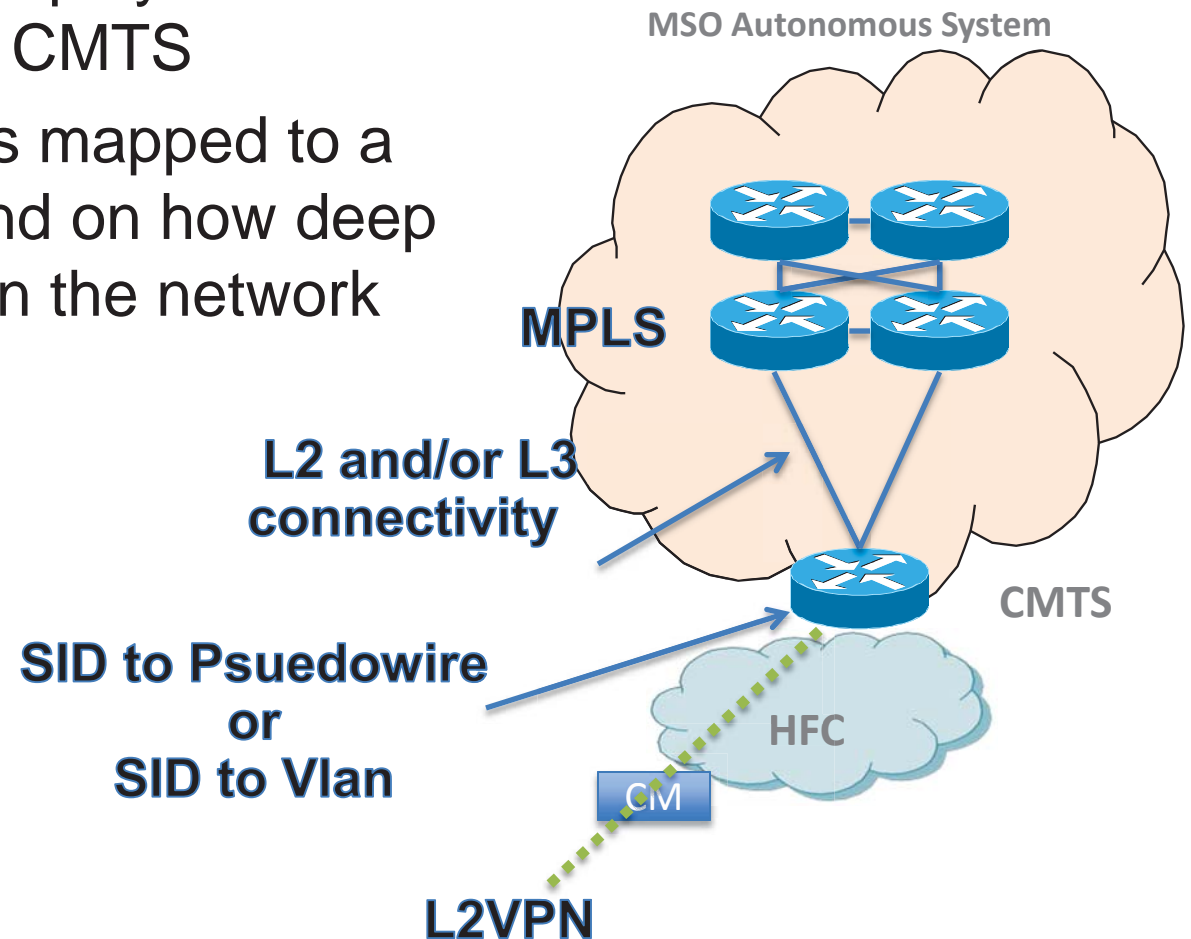- MPLS based Traffic Engineering is deployed by a few cable operators

- Typically the goal is to optimize a networks BW utilization as well as provide FRR protection

TE tunnel 2 (Best Effort)

FRR protection for TE tunnel 1 (Voice)

Shortest Path

TE tunnel 1 (Voice)
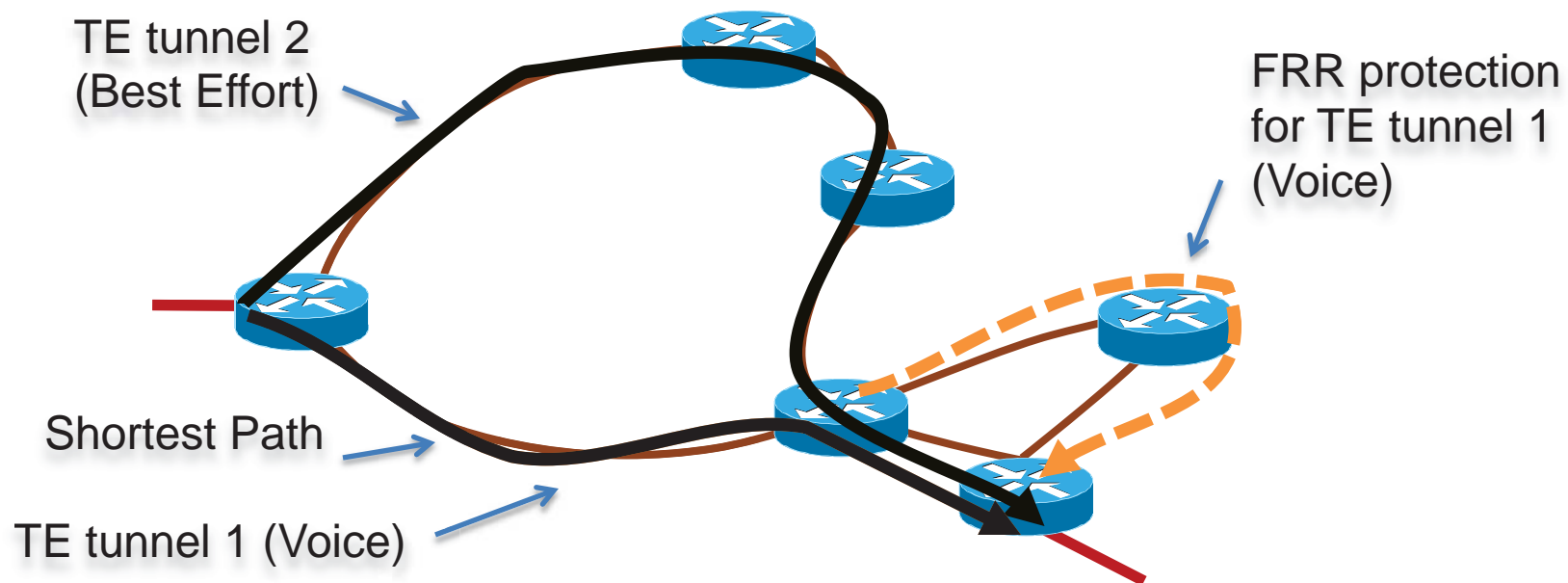
Routing in Cable - MPLS
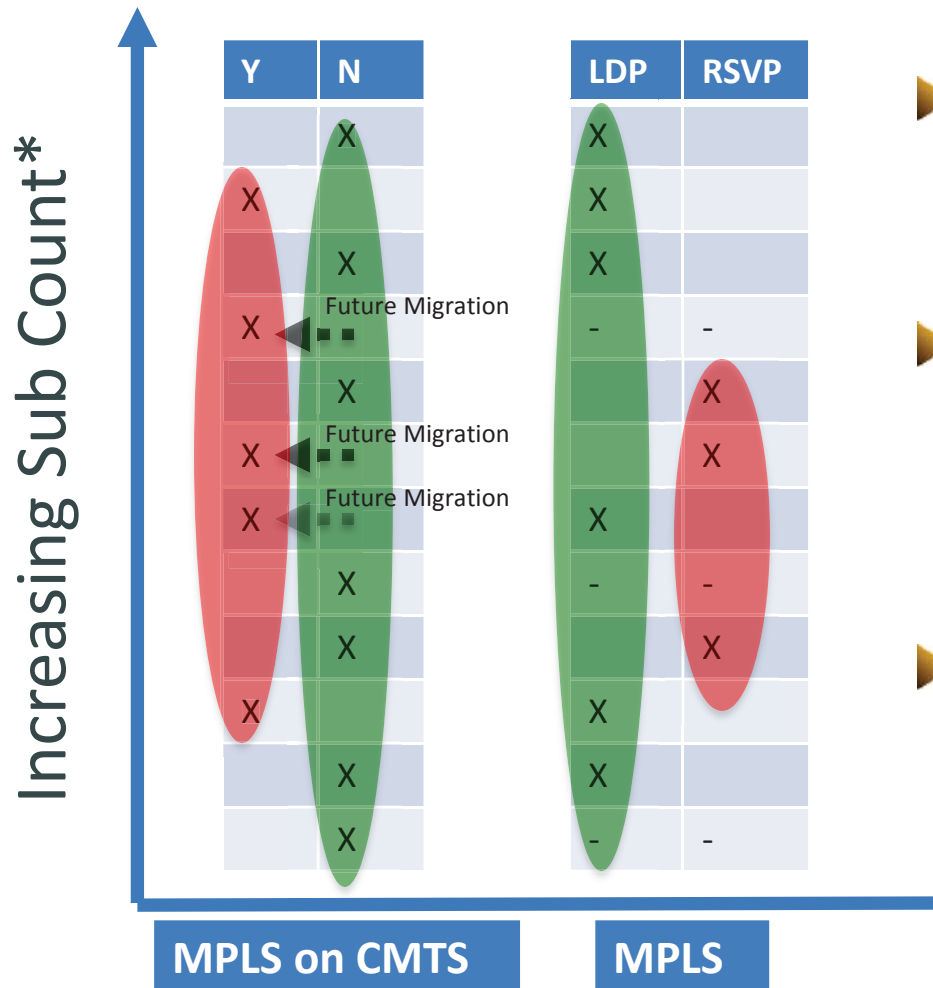
- MPLS is used to deploy L2VPN services off of the CMTS

- How a customer is mapped to a L2 VPN will depend on how deep MPLS is running in the network

MSO Autonomous System

MPLS

L2 and/or L3 connectivity

CMTS

SID to Psuedowire or SID to Vlan

HFC

CM

L2VPN

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Routing Trends – MPLS

Increasing Sub Count*

Y	N
	X
X	
	X
X	Future Migration
	X
X	Future Migration
X	Future Migration
	X
	X
X	
	X
	X

MPLS on CMTS

LDP	RSVP
X	
X	
X	
-	-
	X
	X
X	
-	-
	X
X	
X	
-	-

MPLS

- MPLS on the CMTS is gaining traction many are investigating
- Providers are using other techniques to provide VPN services off of the CMTS
- Majority of MPLS users are using LDP vs. RSVP for transport

MSO listed in random order from small to large

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Summary

- Multiple routing protocols are in use today across Cable architectures.

- Cable operators tend to ebb and flow towards similar architectures/solutions.

- BGP, PIM and MPLS on the CMTS is gaining momentum.

- Cable networks are constantly evolving

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