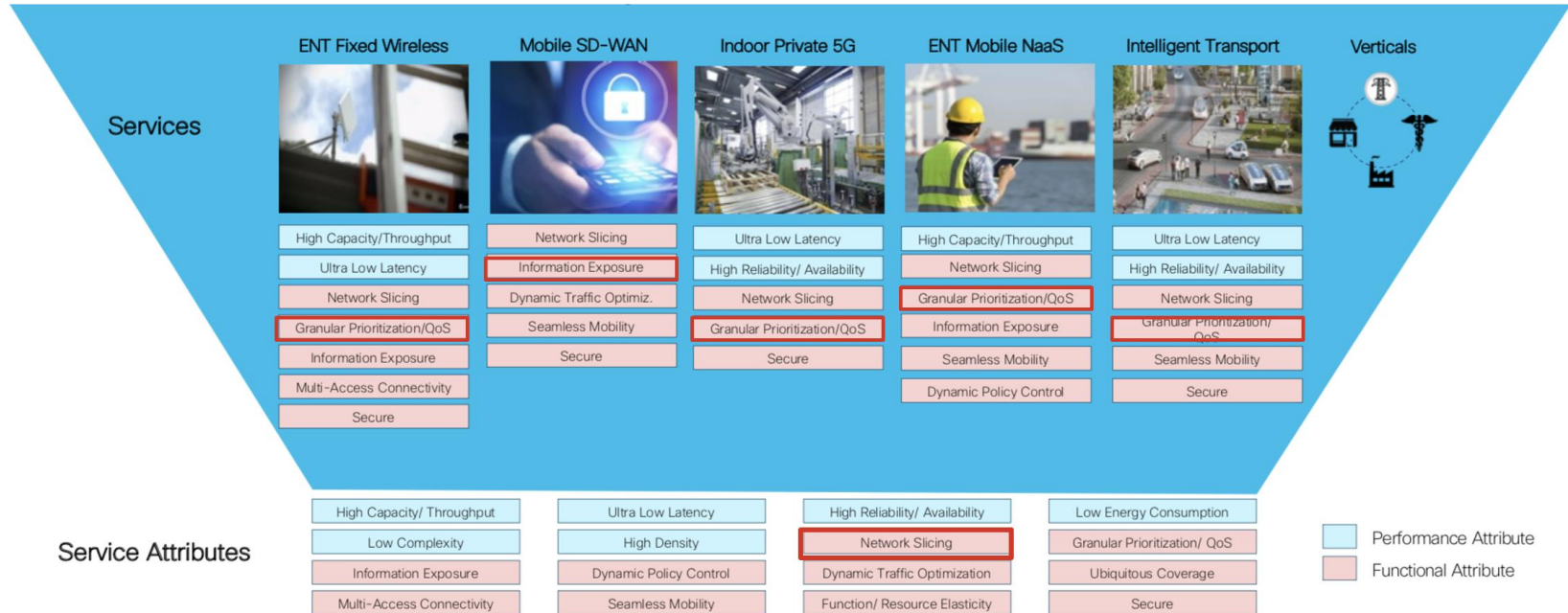# Agenda

- Introduction

- 5G Transport Slicing

- Transport Slice Automation with Orchestrator

- Transport Slice Automation Using Yang

- End to End Slicing

- Summary

Why Slicing matters?
5G Slicing is an underlying capability for all future SP services

Services

ENT Fixed Wireless	Mobile SD-WAN	Indoor Private 5G	ENT Mobile NaaS	Intelligent Transport	Verticals
High Capacity/Throughput	Network Slicing	Ultra Low Latency	High Capacity/Throughput	Ultra Low Latency	
Ultra Low Latency	Information Exposure	High Reliability/ Availability	Network Slicing	High Reliability/ Availability	
Network Slicing	Dynamic Traffic Optimiz.	Network Slicing	Granular Prioritization/QoS	Network Slicing	
Granular Prioritization/QoS	Seamless Mobility	Granular Prioritization/QoS	Information Exposure	Granular Prioritization/ QoS	
Information Exposure	Secure	Secure	Seamless Mobility	Seamless Mobility	
Multi-Access Connectivity			Dynamic Policy Control	Secure	
Secure					

Service Attributes

High Capacity/ Throughput	Ultra Low Latency	High Reliability/ Availability	Low Energy Consumption
Low Complexity	High Density	Network Slicing	Granular Prioritization/ QoS
Information Exposure	Dynamic Policy Control	Dynamic Traffic Optimization	Ubiquitous Coverage
Multi-Access Connectivity	Seamless Mobility	Function/ Resource Elasticity	Secure

☐ Performance Attribute
☐ Functional Attribute

Why do you care about Network Slicing?
Deliver differentiated service and new revenue stream

New Customers
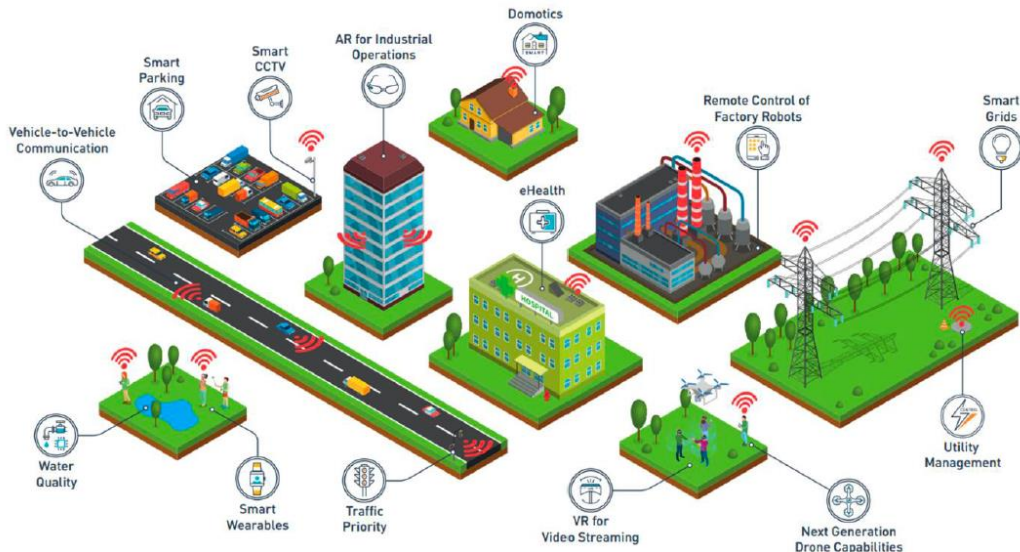Increase adoption of 5G among Enterprises

New Services
Capture a larger share of the value chain

New Business Models
Premium pricing for demanding use cases

Source: Analysys Mason, 2020

# Network Slicing - The Technical Concept

- Ability to run multiple logical networks as virtually independent business operations on a common physical infrastructure

  - Simultaneous support strict SLA requirements and best effort traffic over same infrastructure

- A slice can be dynamically created, modified or deleted without impacting other slices

- Network slicing goes hand-in-hand with SDN, NFV, Network Programmability and Orchestration

- *End-to-End partitioning inherently spans multiple domains and includes RAN, Mobile Core, IP/MPLS Transport, Data Center and Enterprise, etc*
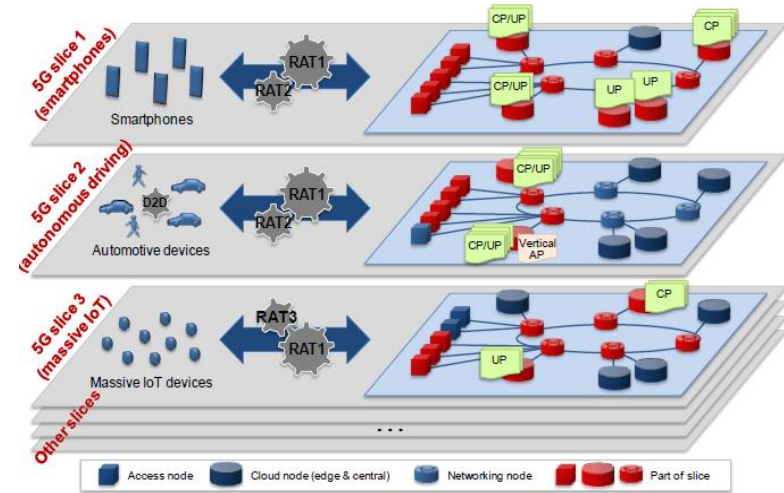
NGMN, 5G whitepaper

Defining Transport Slicing Scope:
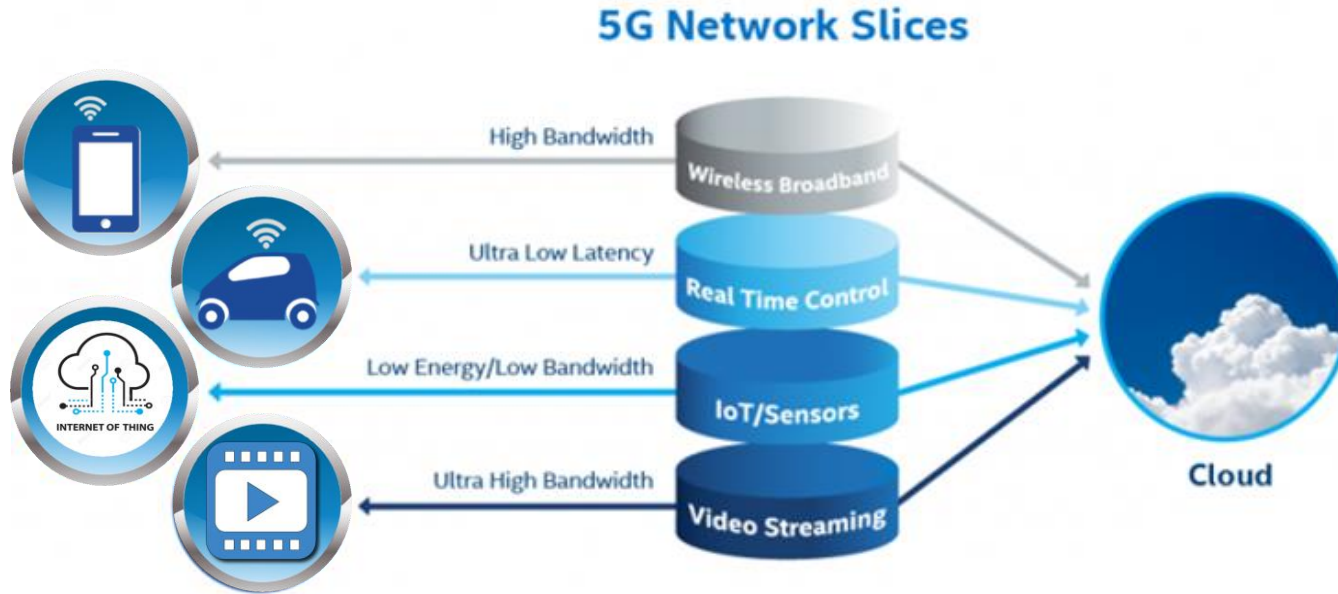# 3GPP reference architecture for 5G network slicing
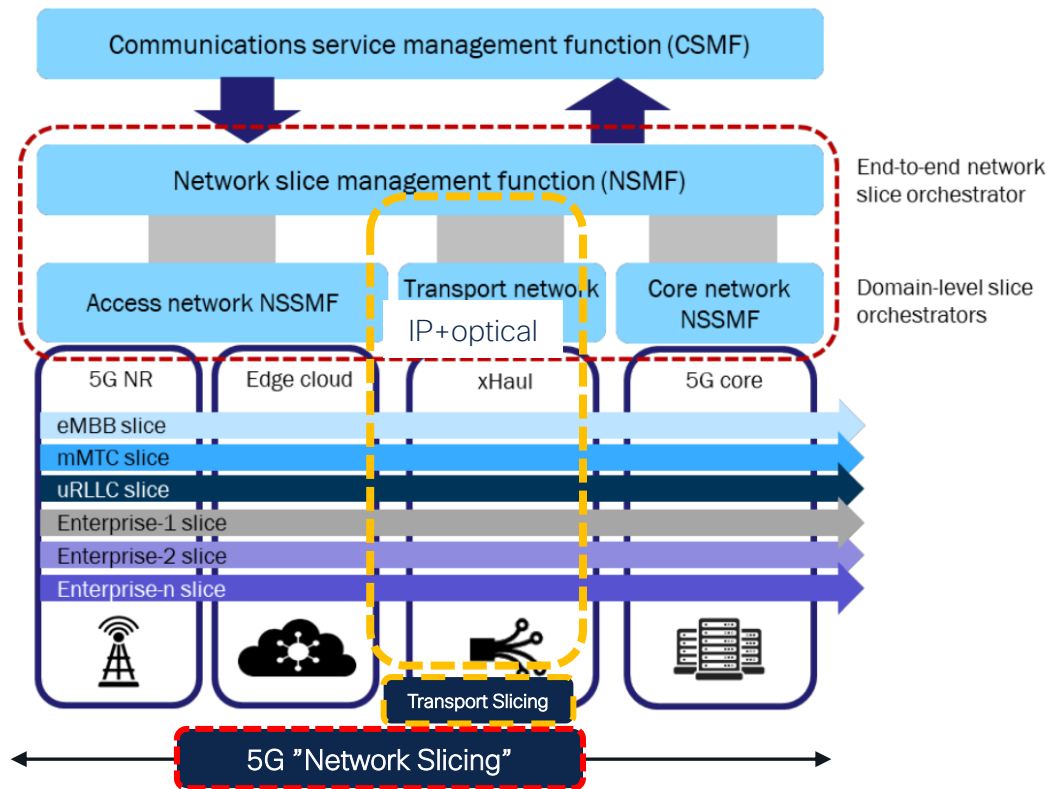
NSMF= Network Slice Mgmt. Function
NSSMF= Network Slice Subnet Mgmt. Function

Scope of 5G _Network_ slice management
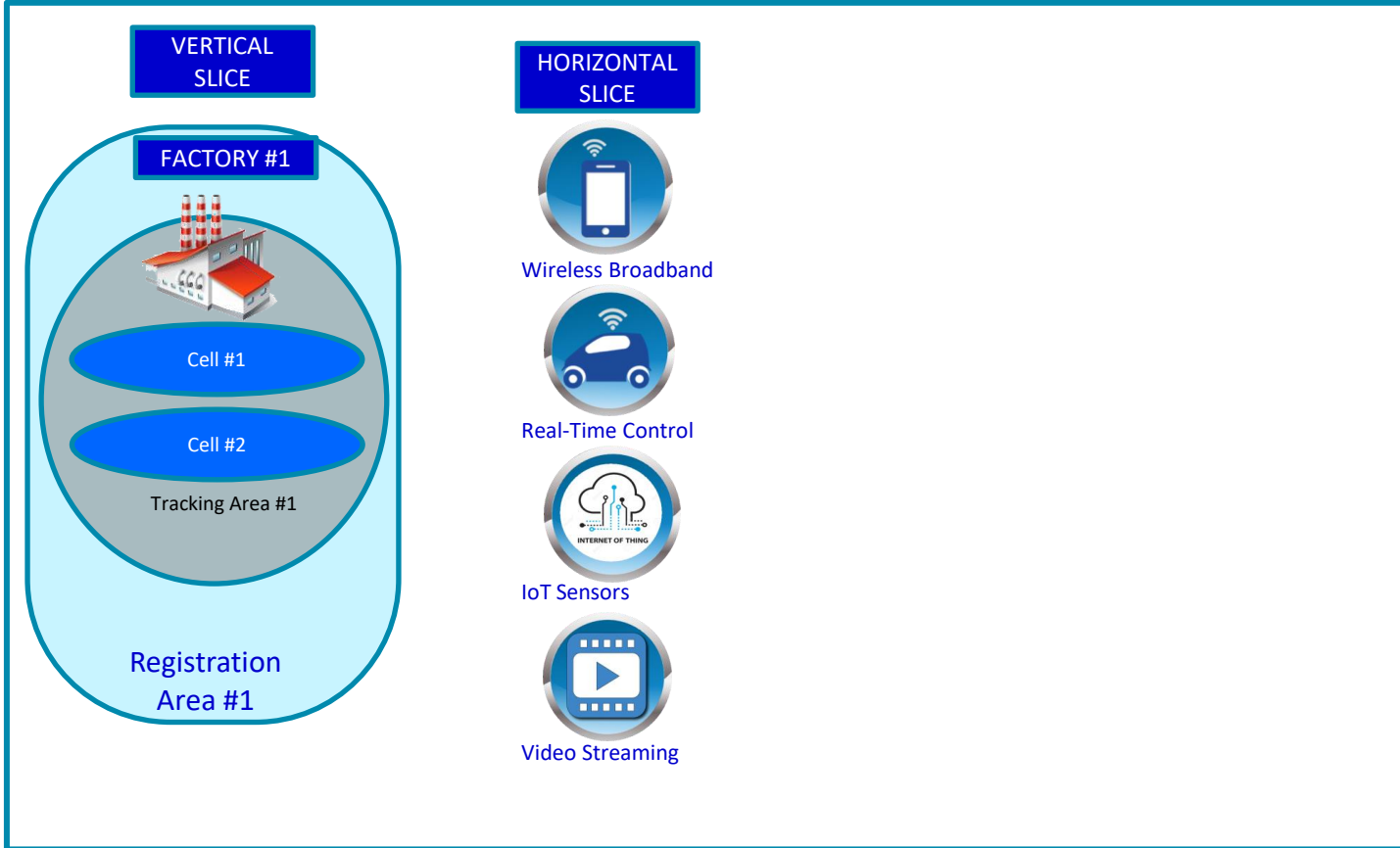
Scope of _Transport_ slice management
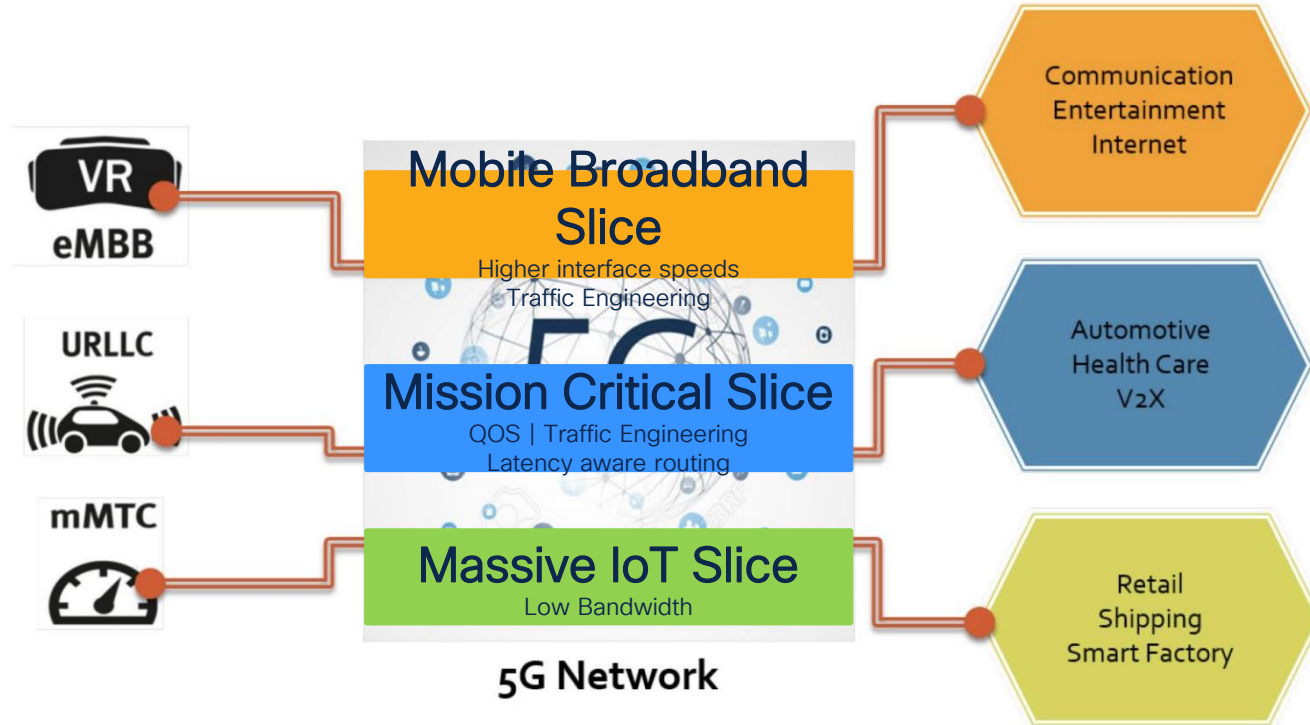
5G RAN Slicing

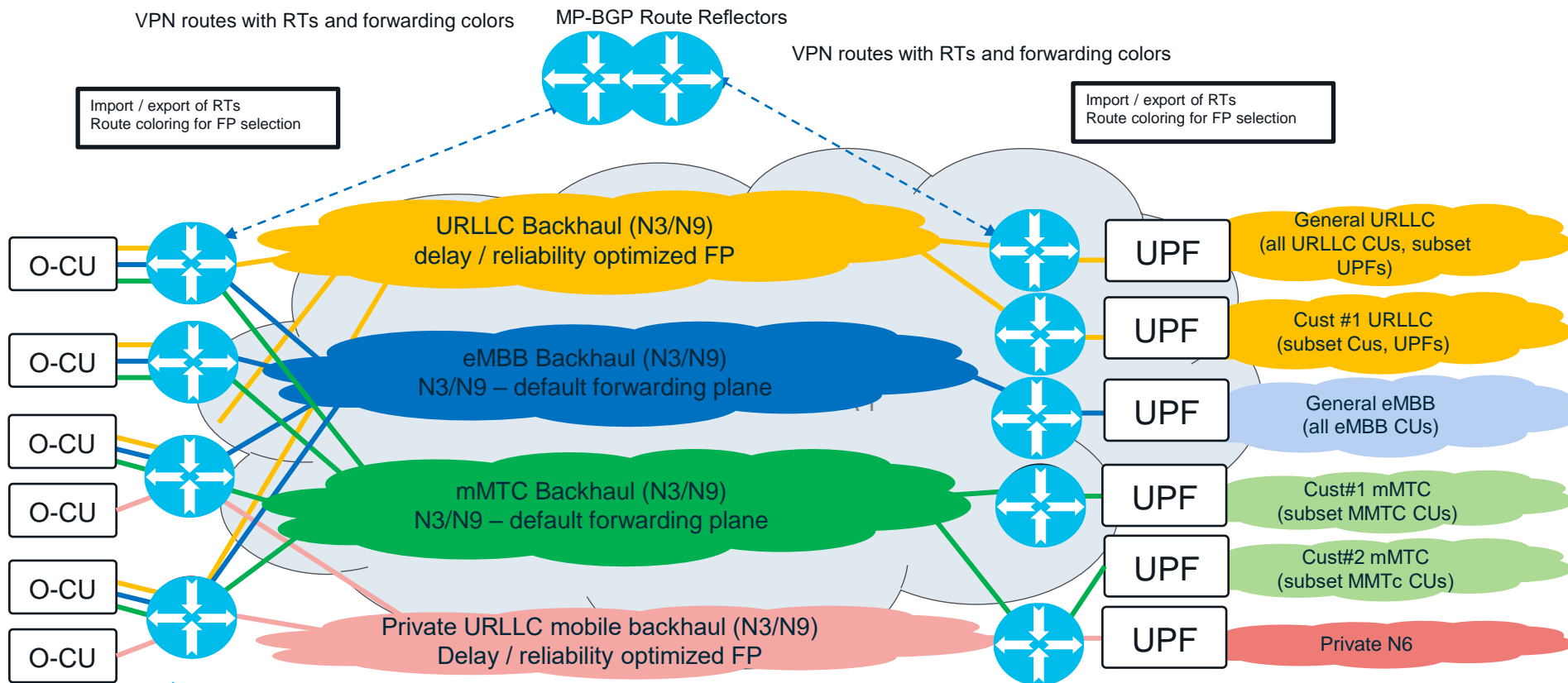# 5G Network Slices (Example)

Slice Groups

5G Transport Slicing

5G Network Transport Slicinig Use Cases

Slicing is seen as a key capability for 5G

VR
eMBB

URLLC

mMTC

Mobile Broadband Slice
Higher interface speeds
Traffic Engineering

Mission Critical Slice
QOS | Traffic Engineering
Latency aware routing

Massive IoT Slice
Low Bandwidth

5G Network

Communication
Entertainment
Internet

Automotive
Health Care
V2X

Retail
Shipping
Smart Factory

CISCO Live!

VPN with automated steering for isolation and path selection

VPN routes with RTs and forwarding colors

MP-BGP Route Reflectors

VPN routes with RTs and forwarding colors

Import / export of RTs
Route coloring for FP selection

Import / export of RTs
Route coloring for FP selection

O-CU

URLLC Backhaul (N3/N9)
delay / reliability optimized FP

eMBB Backhaul (N3/N9)
N3/N9 – default forwarding plane

mMTC Backhaul (N3/N9)
N3/N9 – default forwarding plane

Private URLLC mobile backhaul (N3/N9)
Delay / reliability optimized FP

UPF

General URLLC
(all URLLC CUs, subset UPFs)

Cust #1 URLLC
(subset Cus, UPFs)

General eMBB
(all eMBB CUs)

Cust#1 mMTC
(subset MMTC CUs)

Cust#2 mMTC
(subset MMTc CUs)

Private N6

End-to-End Transport Network Slice

Slice mapping using Destination Prefix, VLAN or Interface

Slice mapping using Destination Prefix, VLAN or Interface , VRF

RAN

IP Handoff

QI to DSCP

AN1

Slice plane 2 – eMBB Shared (Low Delay path)

Slice plane 1 – FWA (Best TE-Metric)

AN3

IP Handoff

QI to DSCP

RDC or CDC

Infra L3out

New Slice/VRF/Prefix

Border Leaf

SR enabled MBH

SRTE/ SRTE-FlexAlgo & VRF & QoS
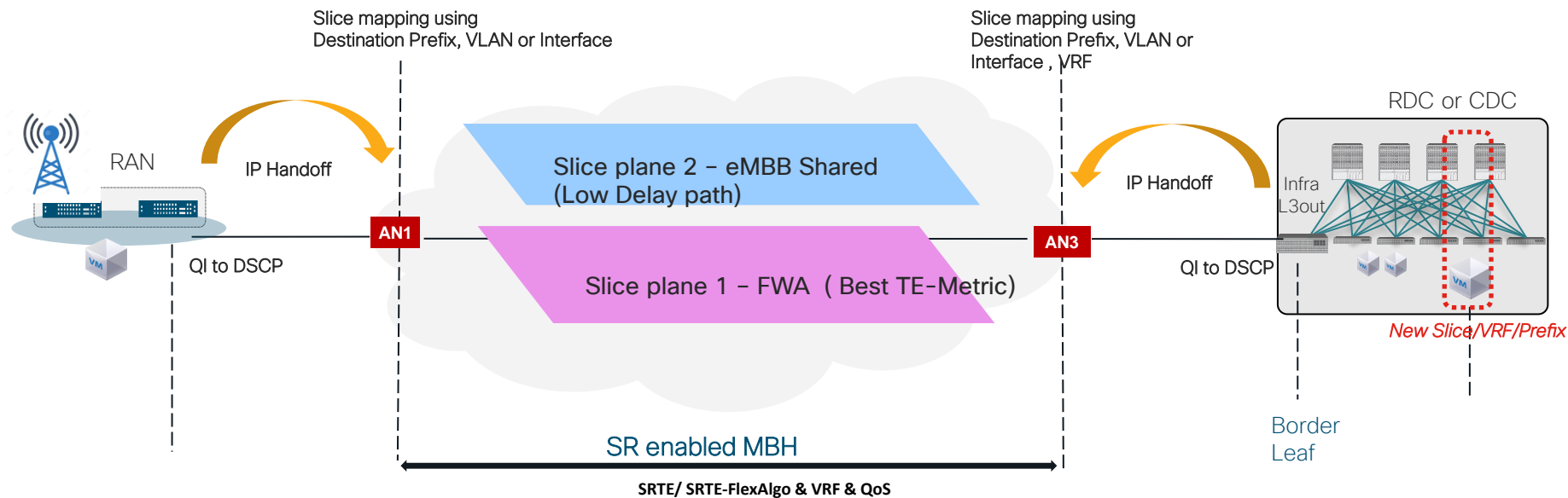
SR-PM 2-Way
FA CSPF

SR is the Slicing & Convergence Enabler
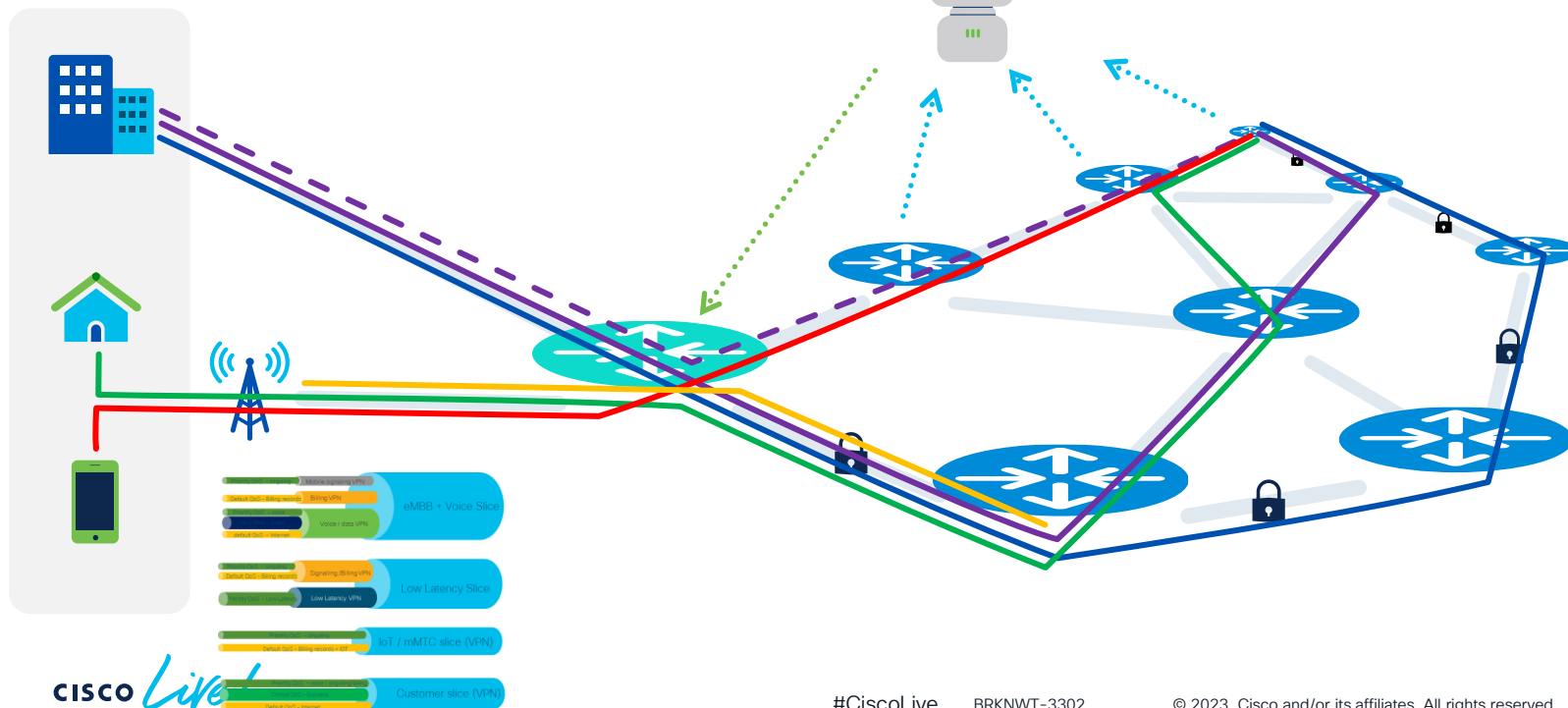
Intent-based Automated Steering

Applicability Examples

Service Portal

Pay as you Go

Application Awareness

SLA fulfillment

Solution

Services **automatically steered** on the right SR policy **based on color** of the service route

Delivers across the unified SR Fabric **the SLA requested** by the service

Benefits

Simplicity, automation and scale

Optimal use of resources
No performance penalty

Higher Performance

Shipping

Unique Functionality

BGP update:
T/t via Node 4
with **color PURPLE**

Intent:
Min-delay metric transport path

RR

5 1 2

8 3

D: 10

6 7 4

D: 10

T/t

D = Measured link Delay (default 1)

HE automatically steers traffic for a colored prefix onto right SR policy

SRTE policy from node 6 to node 4 providing a desired transport SLA (e.g. delay optimized)

Interested? Segment Routing Traffic Engineering (SRTE) on segment-routing.net

CISCO Live!

Intent-based Per-Flow Automated Steering

Applicability Examples

Service Portal

Pay as you Go

High Bandwidth

UHD Video

Application Awareness

SLA fulfillment

Solution

Per-flow (per class) Services are **automatically steered** on the right SR policy **based on their specific color**

Delivers Flow/Class awareness across the unified SR Fabric **the SLA requested** by the service

Benefits

Flow/Class aware Simplicity, automation and scale

Optimal use of resources

HE performs traffic classification on ingress interface according to operator needs and sets forwarding class (FC)

BGP update:
T/t via Node 4
with **color BLUE**

Intent:
per-flow steering

RR

Flow 1 –

Flow 2 –

D: 1
I: 100

T/t

Office 365

HE with **"Per-Flow" SR policy {BLUE, Node 4}**, where:
  Traffic with FC1 follows IGP shortest path
  Traffic with FC2 follows delay-optimized path

D = measured link Delay (default 10)

I = IGP ink metric (default 10)
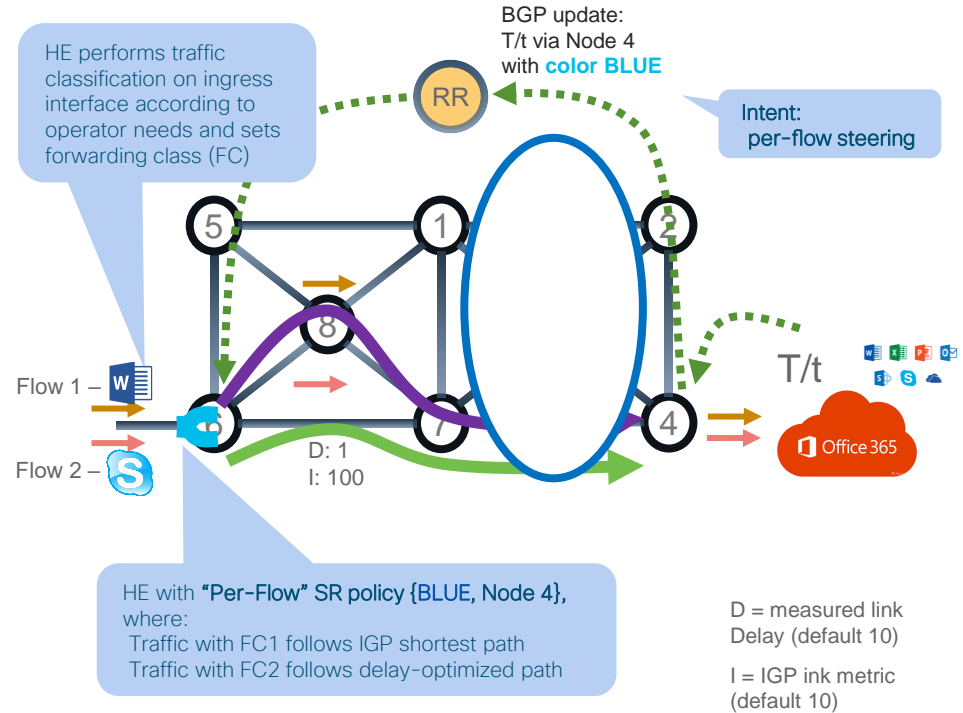
Interested? Segment Routing Traffic Engineering (SRTE) on segment-routing.net

SR IGP Flexible Algorithms

Applicability Examples

Sensitive Data

$

Financial Transactions

Transport
Redundancy
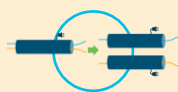
Different Fiber
Conduits

Scalability

Low-End Platforms

Solution

Customized IGP algorithms defined by operator for **intent-based instantiation of traffic Engineering**
Minimization of metrics: IGP, delay
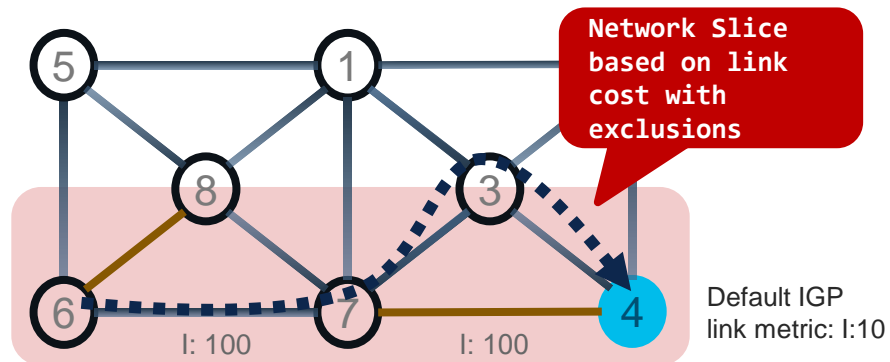Exclusion of properties: link-affinity, SRLG

Benefits

Simplicity and Automation
IGP-computed TE-path from anywhere to anywhere
Sub-50msec protection (TILFA) optimized per Flex-Algorithm plane

Scalability
Single SID (instead of label stack) to enforce TE path
Single prefix segment can participate in many Flex-Algos

Network Slice based on link cost with exclusions

I: 100   I: 100

Default IGP
link metric: I:10

Network Slice based on delay

D: 10

Measured link
Delay: D:1
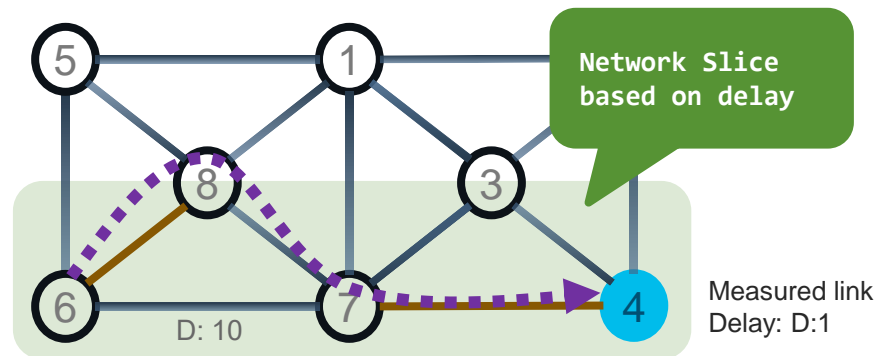
Interested? SR IGP Flexible Algorithm on segment-routing.net

Virtual Topologies via FlexAlgo

- Virtual topology with specific characteristics
  - Can use all or parts of the physical topology
  - Metric-type(s)
    - IGP metric
    - Link delay*
  - Link avoidance
    - Link affinity
    - SLRG

vtopo 3 – flexalgo 129

vtopo 2 – flexalgo 128

vtopo 1 – algo 0

physical topology
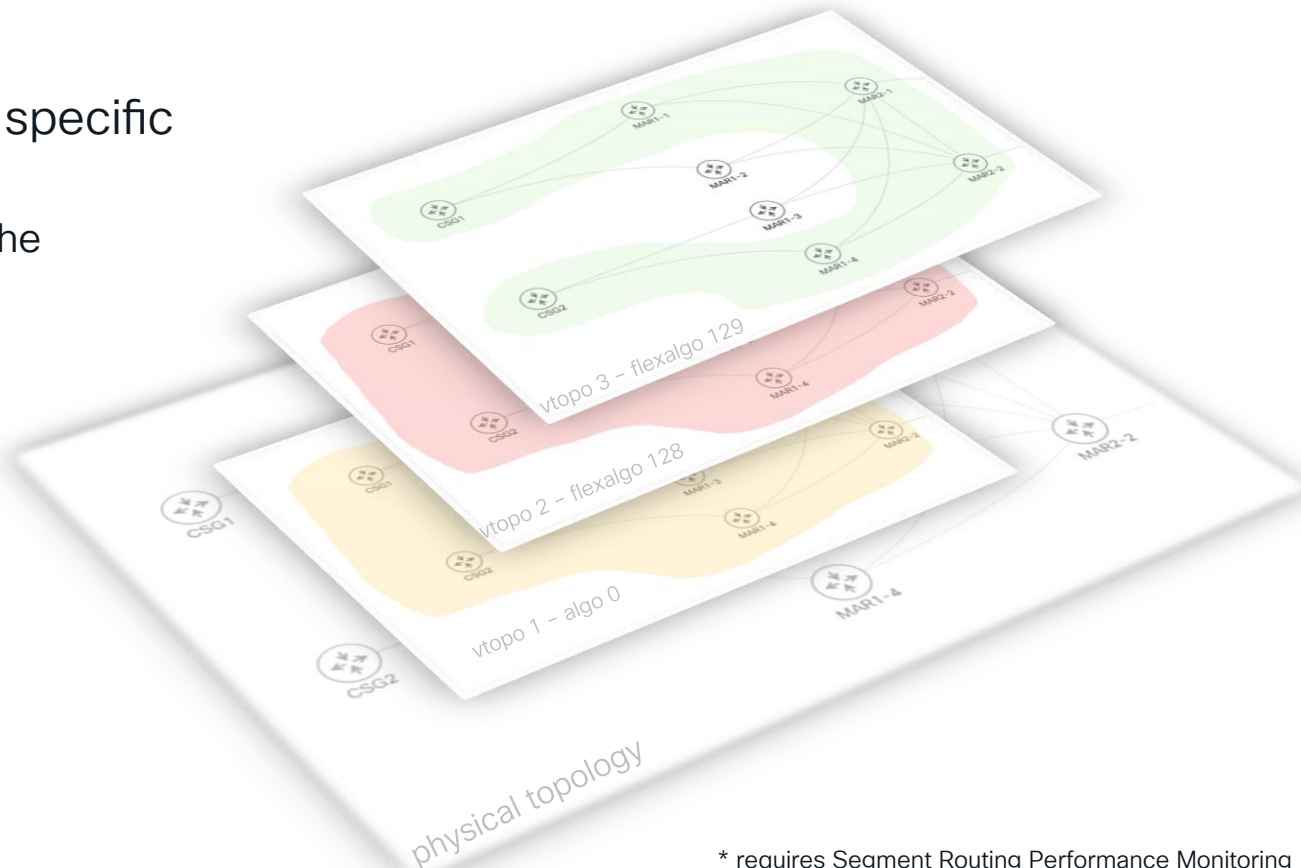
Flexible Transport Network Slicing Model

- We can combine Algo/FlexAlgo with VPNs

- Multiple VPNs can use a specific virtual topology (Algo/FlexAlgo)

- Flexible and resource efficiency

We can build slices with Algo/FlexAlgo

VPN D

VPN C

Delay optimized

vtopo 2 – flexalgo 128

VPN B

VPN A

Bandwidth optimized

vtopo 1 – algo 0
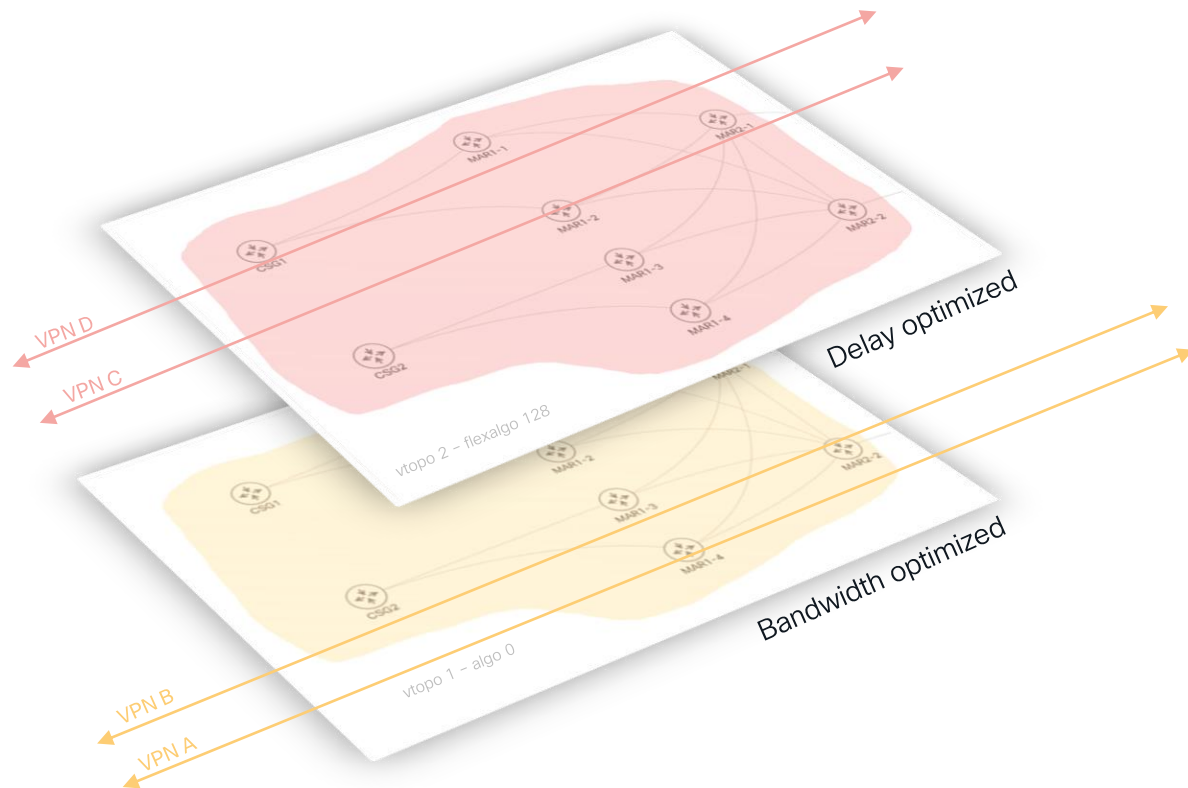
SRv6 Transport Slice As-a-service

SRv6
(IP-in-IP)

SRv6 L3VPN
(over SRv6 TE)

IP

Content

P4/VPP GW

PE

PE

Default

PE

PE

Edge

Low Latency
High reliability

Edge

Metro

Metro

PE

PE

Acce ss

High BW
Low Cost

PE

PE

Acce ss

Eyeball

Eyeball

Acce ss

Acce ss

Content

P4/VPP GW

Backbone

PE

PE

Peering
Fabric

Internet

- VRF
- Flex-Algo
- SRv6 TE
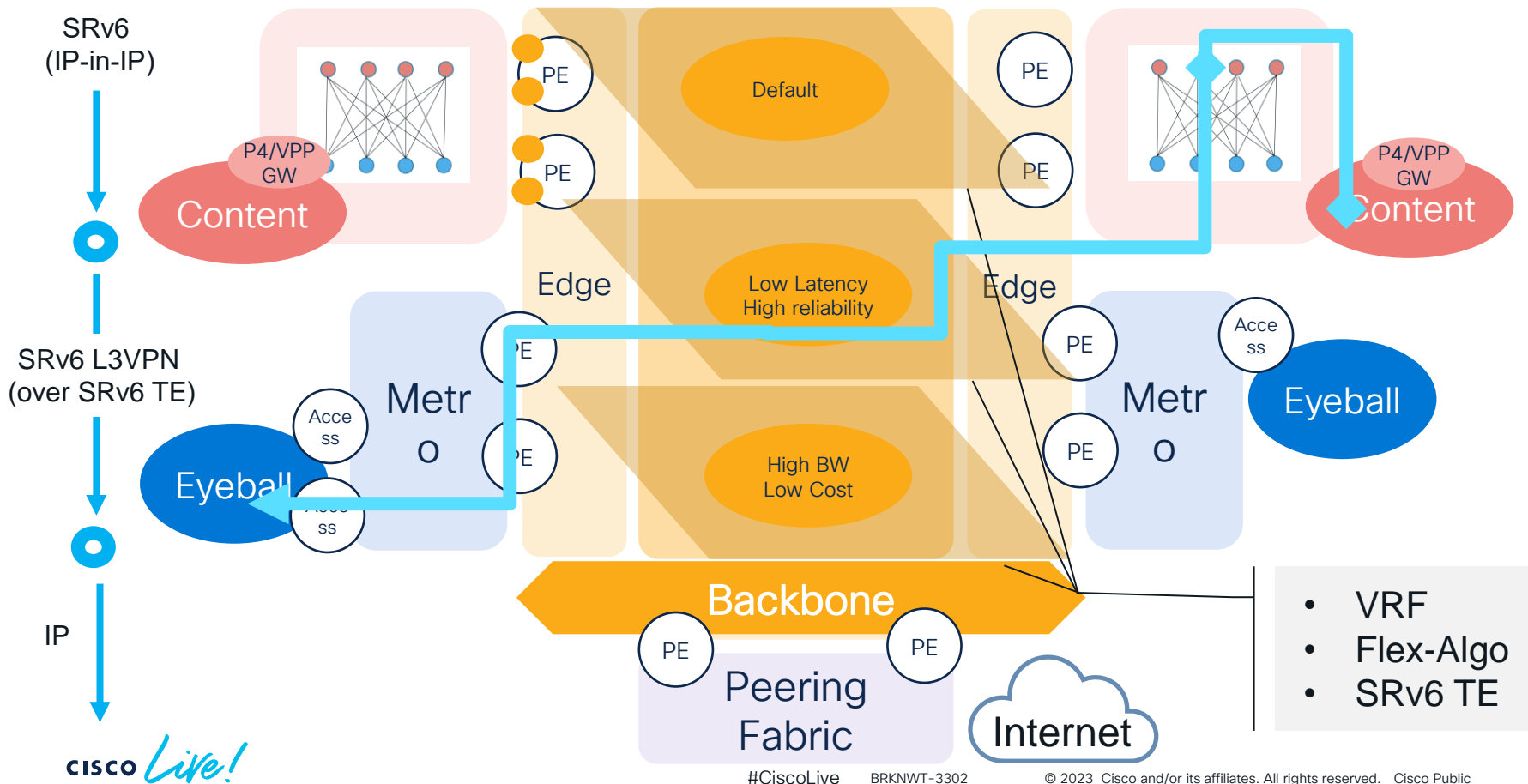
O-RAN 5G Transport Architecture

Adapted from O-RAN WG-9 Packet Switched xhaul Architecture and Solutions
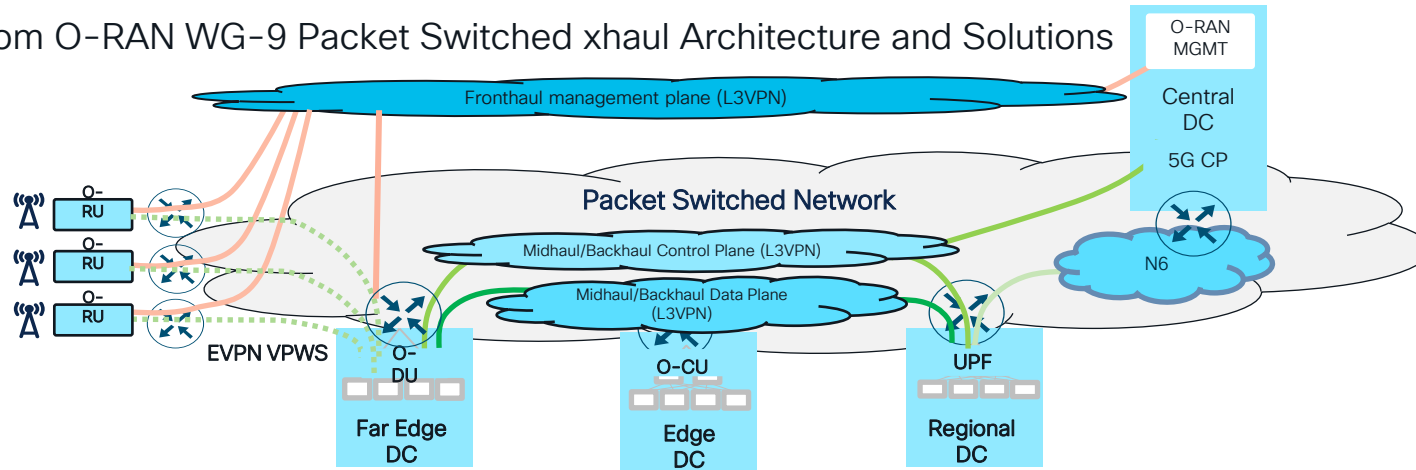
O-RAN WG-9 "Packet switched architectures and solutions" outlines followings:

- Segment Routing based on MPLS or IPv6 packet switched network
- Ethernet VPWS services for fronthaul interfaces with priority queuing
- BGP based L3 VPN for O-RAN 7.2X M-Plane
- BGP based L3 VPNs for midhaul / backhaul
- Appropriate packet based QoS and forwarding plane for the 5G service

O-RAN 5G Transport Slicing Architecture

Adapted from O-RAN WG-9 Packet Switched xhaul Architecture and Solutions

- 5G transport slicing
  - Transport separation between Fronthaul, Midhaul, Backhaul interfaces.
  - Transport separation between Control, management, and user plane interfaces of each domain.
  - Connectivity, isolation, and Quality of Service (QoS) so management, control and user plane traffic can flow between the mobile components, making up a slice, in an appropriate fashion
  - Flexible mapping of Network Slice Instances (NSIs) to physical or logical transport network instances.

Transport Slice Automation with Orchestrator

Automation Strategy to address Customers' Requirements

- **Slice provisioning**
  - Intent-based slice definition that abstracts the underlying components:
    L2, L3, QOS, FlexAlgo, SRv6, OAM...
  - **Slice template catalog** that includes pre-defined slice templates

- Slice provisioning through **Standardized APIs** (IETF most likely)
  - IETF Slice Yang Model exposed to E2E Orchestrator

- **Slice visualization**
  - Per Transport Slice Observability that includes
    - VPN
    - SR-TE Paths / Flex-Algo Paths

- **Slice performance monitoring** in near real-time
  - Path Performance (Latency/Loss/Jitter)
  - BW statistics
  - Future: QoS statistics

CNC 5.0 And 5G Transport Slicing

Building Blocks
- FlexAlgo support
- SRv6 support
- L2VPN/L3VPN enhanced NSO Function Packs
- QOS support

NSST Name	Slice Type Value	Description	QoS Plane Profile	Forwarding Plane Policy
eMBB	1	Use High BW links	Soft-Shared-Queues	IGP
URLLC	2	Use low-delay links	Soft-Shared-Queues	min-delay
mMTC	3	Use low-delay links	Soft-Shared-Queues	min-delay
Encrypted	4	Transit MACsec encrypted links only	Soft-Shared-Queues	encrypt
Disjoint-Path-Top-Rail	5	Only transit links marked top-rail	Soft-Shared-Queues	top-rail
Disjoint-Path-Bottom-Rail	6	Only transit links marked bottom-rail	Soft-Shared-Queues	bottom-rail
20ms-max-delay	7	Delay not to exceed 20ms e2e	Soft-Shared-Queues	NTE-20ms
30ms-max-delay	9	Delay not to exceed 30ms e2e	Soft-Shared-Queues	NTE-30ms

Slice Creation Abstraction
- Simplified UI to abstract the Slice components
- Slice Template Catalog

Slice Lifecycle
- Overlay maps
- KPI collection and Closed-Loop Automation
- Network Optimization

Transport Slicing in CNC 5.0: Visualization

Slice list including type and provisioning state
(*Note: No Slice Health monitoring in 5.0*)

New menu for Transport Slice and Catalog

Navigate the Slice components: VPN, Transport

Display a slice on the map

Drill-down to VPN and/or Transport details

From the VPN list, display VPN details including Assurance data if monitoring is enabled

From the Transport list, display SR TE details including SR-PM data if SR-PM is enabled

Simplified Transport Slice Creation

Specify Slice ID, Service Type, NSST Template…

Specify Connectivity Type, Isolation, Bandwidth…

Define Service Demarcation Points

IETF Network Slice NB Model – SLO-SLE Templates

Yang Tree – SLO SLE Template

cisco-sr-te-odn:odn-template- use "as-is" or "as-blueprint"

Service Assurance

QoS Catalog - Policy-Map pre-configured or available in network

Continued...

IETF Network Slice Model – Network Slice Service
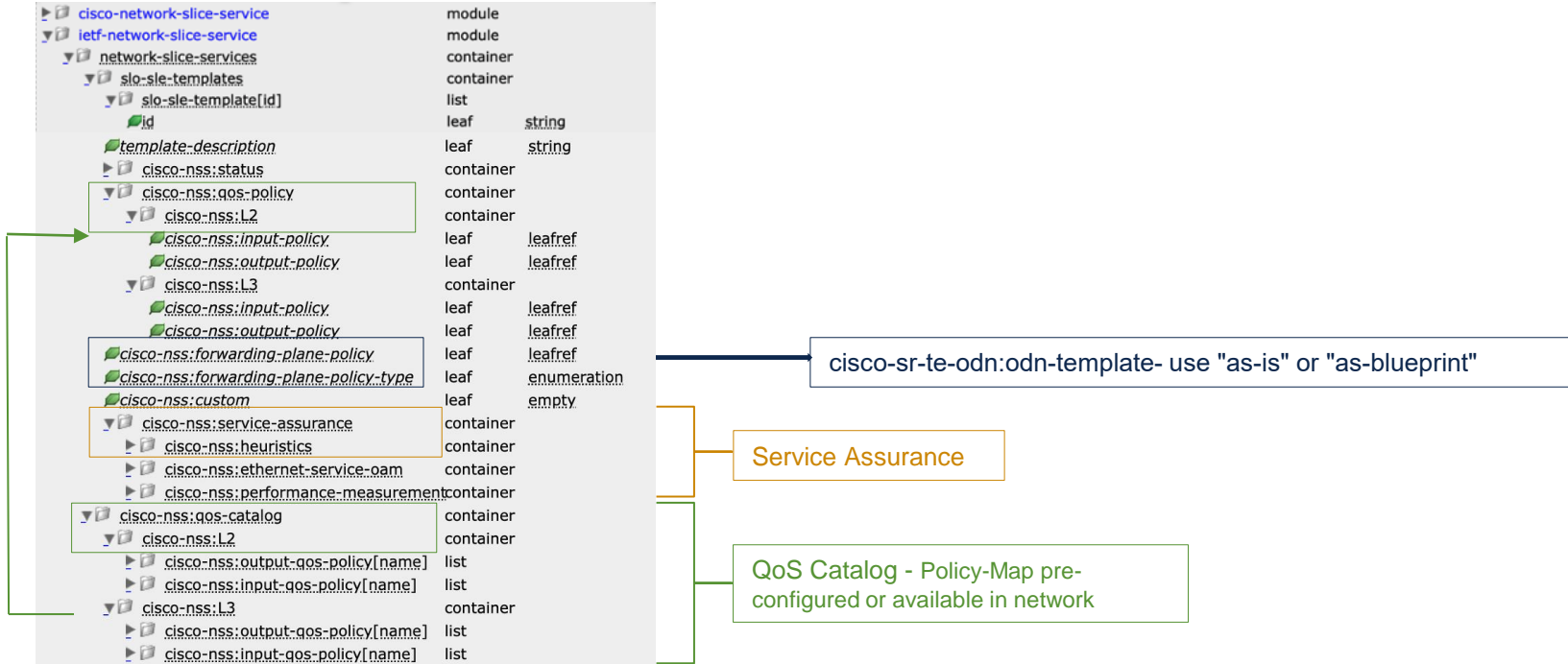
Yang Tree – Slicing Service

▶ 🗀 cisco-network-slice-service	module	
▼ 🗀 ietf-network-slice-service	module	
▼ 🗀 network-slice-services	container	
▶ 🗀 slo-sle-templates	container	
▼ 🗀 slice-service[service-id]	list	
🍃 service-id	leaf	string
🍃 service-description	leaf	string
▼ 🗀 service-tags	container	
▼ 🗀 tag-type[tag-type]	list	
🍃 tag-type	leaf	identityref
🍃 value	leaf-list	union
▼ 🗀 (slo-sle-policy)	choice	
▼ 🗀 :(standard)	case	
🍃 slo-sle-template	leaf	leafref
🍃 cisco-nss:isolation	leaf	identityref
▶ 🗀 :(custom)	case	
▼ 🗀 sdps	container	
▼ 🗀 sdp[sdp-id]	list	
🍃 sdp-id	leaf	string
🍃 sdp-description	leaf	string
▶ 🗀 location	container	
🍃 node-id	leaf	leafref
🍃 sdp-ip	leaf	inet:ip-address
▶ 🗀 service-match-criteria	container	
▶ 🗀 sdp-peering	container	
▶ 🗀 attachment-circuits	container	
▶ 🗀 cisco-nss:vpn-targets	container	
🍃 cisco-nss:rd	leaf	route-distinguisher
▶ 🗀 connection-groups	container	
🍃 cisco-nss:rd	leaf	route-distinguisher
▶ 🗀 cisco-nss:shared	container	
▼ 🗀 cisco-nss:service-assurance	container	
▶ 🗀 cisco-nss:heuristics	container	

Slice Definition – L2/L3 and Customer tags

slo-sle-templates/slo-sle-template-id

Type "Dedicated" or "Shared"

Node or Device and UNI connection details

Any-to-Any, Hub-Spoke, Point-to-Point

Association to shared slice

End-to-End Slicing

E2E Architecture Evolution

Access Transport Central Datacenter Services

4G

B/H

Mobile Core
4G Core

Access Transport Central Datacenter Services

3G
5G
4G

F/H Edge DC
M/H Regional DC
B/H

vUPF
vUPF

Mobile Core
Converged Core
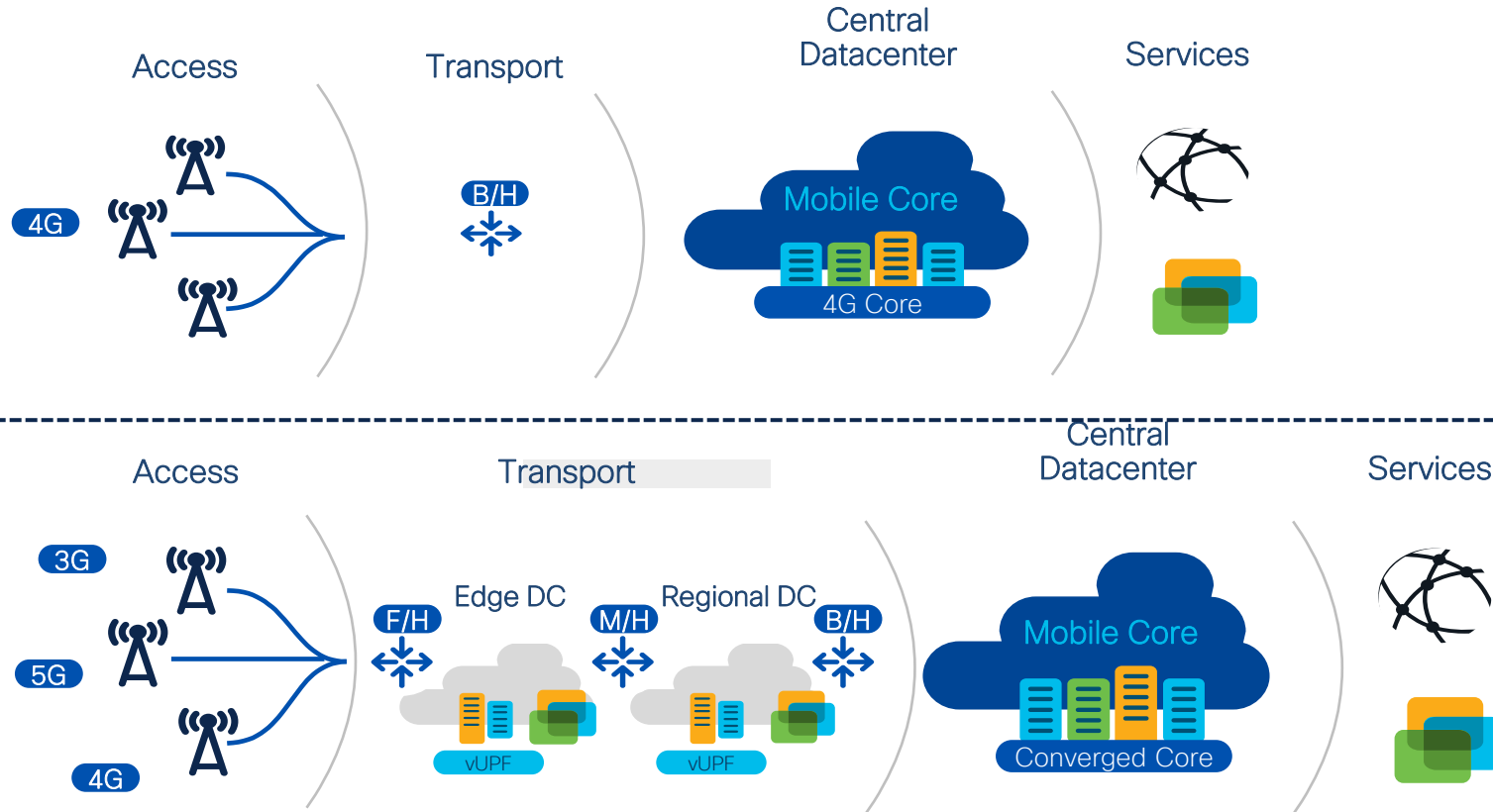
A 5G Network Slice Service spans multiple "Domains"
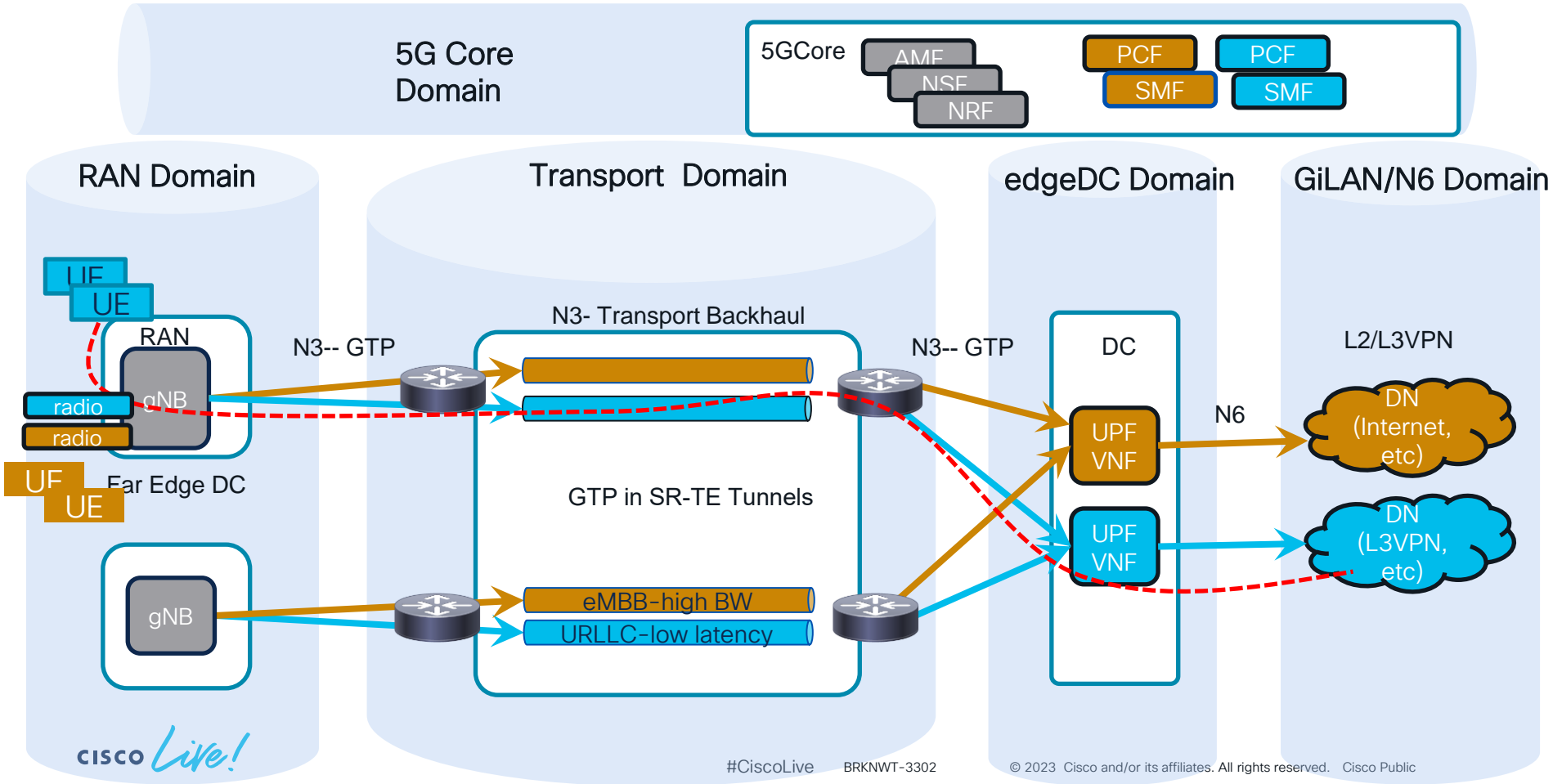
Continue your education

- https://datatracker.ietf.org/doc/draft-srld-teas-5g-slicing/

- https://datatracker.ietf.org/doc/draft-ietf-teas-ietf-network-slices/

Thank you

CISCO *Live!*

#CiscoLive