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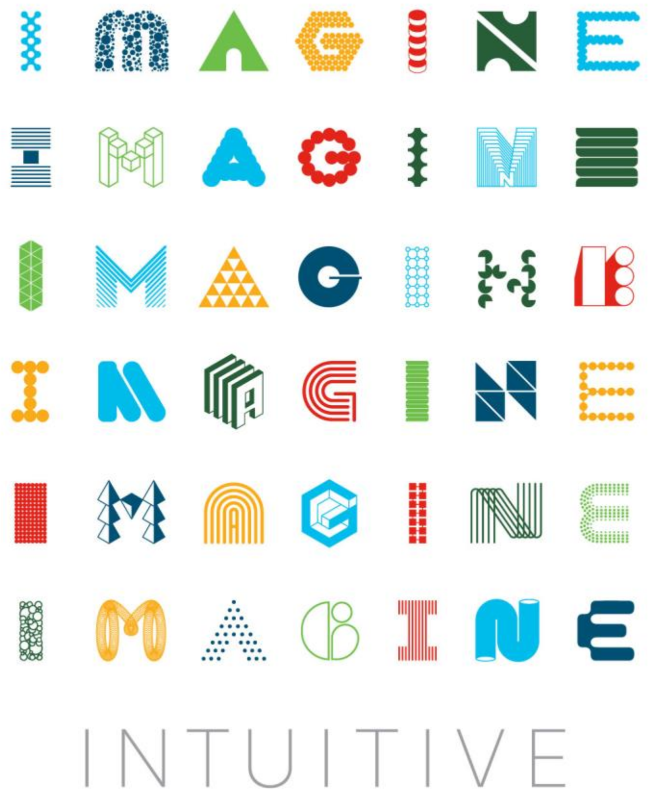
IMAGINE

INTUITIVE

BRKSPM-3001

5G Network Using Segment Routing for Transport

Jakub Horn, Technical Marketing Engineer

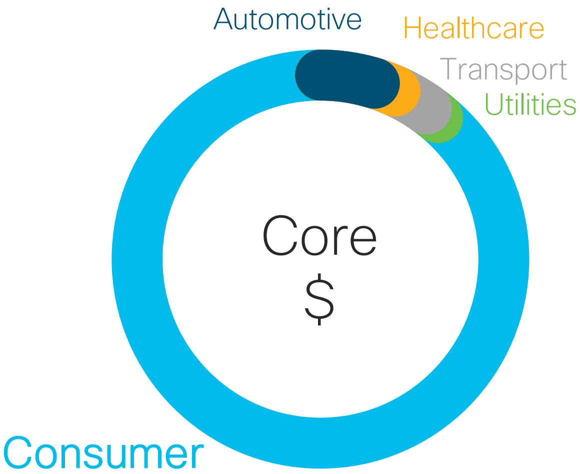


Agenda

- Introduction
- 5G Network Requirements
- Fronthaul
- Low Latency
- Segment Routing
- Network Slicing
- Conclusion

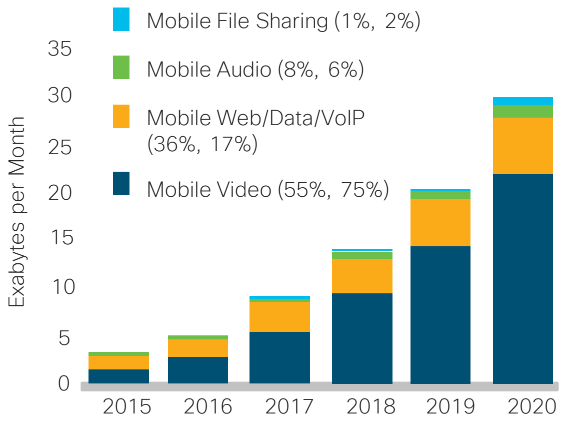
5G Network requirements

Mobile Operator Revenue Growth Opportunities

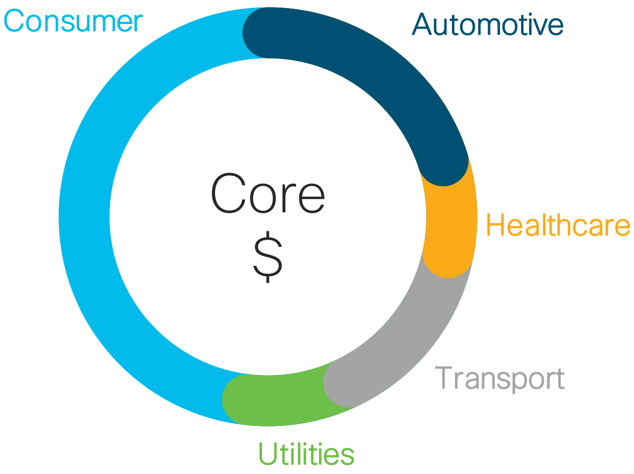


Today
Operator business mostly focused on the saturated consumer market

53% CAGR 2015-2020



Video drives traffic…
but not revenue



2025
Vertically targeted services will accelerate operator business growth

Source: European Commission Report, 2016

5G Service & Network Evolution

Secure Remote Car Software Update

10 - 100M lines of code and hundreds of subsystems

Vehicle updates, telematics, and infotainment

CSP hosted Network Slicing for Public Sector Private Networks

Police, fire, hospitals with strict SLAs and Security

Smart City Enablement

Smart-sensor enabled

Waste and recycling,, parking, smart grid, homes

Augmented / Virtual Reality Delivery

Augmented, virtual, and mixed reality for learning, gaming, 4K/8K

Video enablement required

Enhanced Mobile Broadband
1000x BW, 10-100x
50 msec – 300 msec

Ultra Reliable Low Latency Communication
~1 – 25 msec Latency

Massive Machine Type Communications
1000x Density

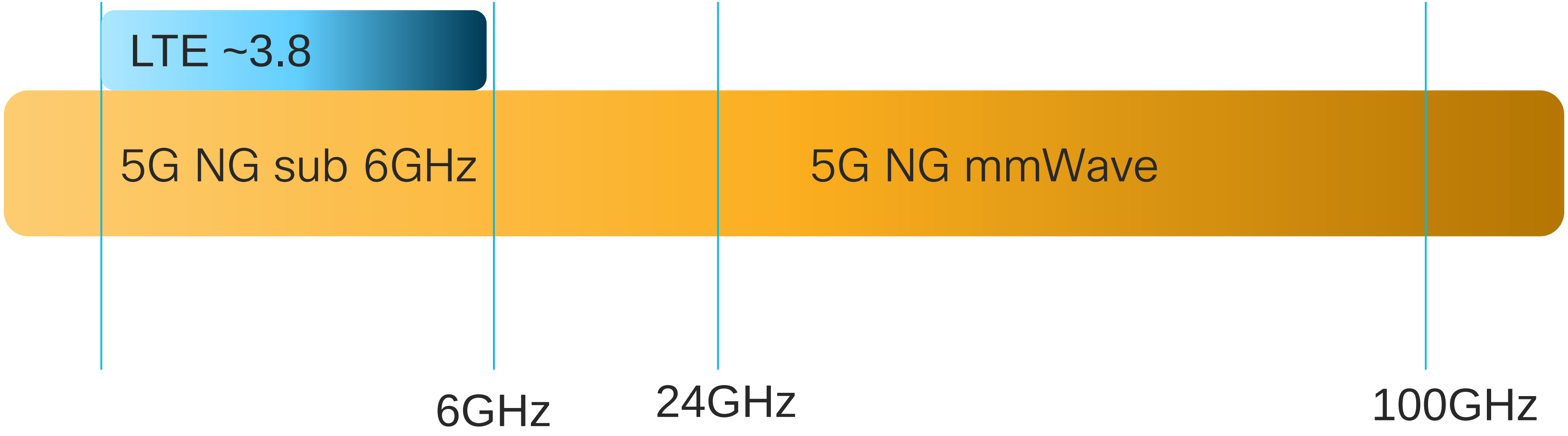
Increased Bandwidth and Capacity

Push data plane to the edge (MEC) - Micro Datacenters

Slicing, Flexible deployment, NFV/Virtualization

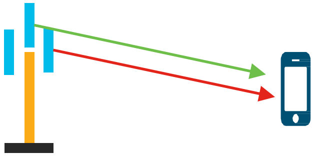
Frequencies

Universal technology across all bands

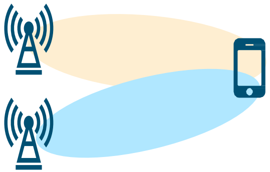


*LTE Bands 46,47,252,255 up to 6GHz

Synchronization Requirements



Transmission Diversity
±12.5ns Phase Accuracy
Improves error performance
Data Rate or Capacity



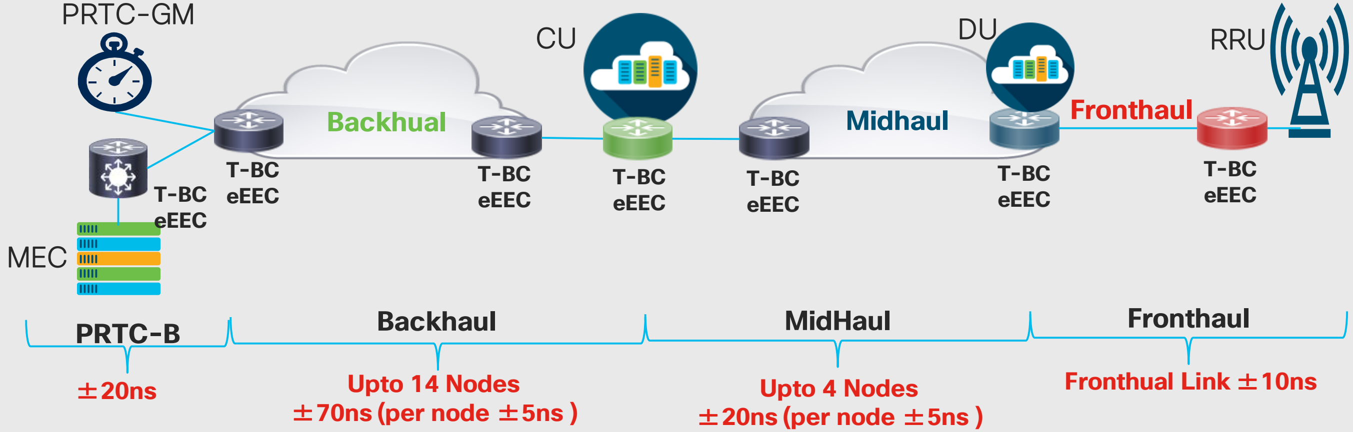
Carrier Aggregation
±65ns Phase Accuracy
Higher Pick Date Rate
More Bandwidth
Better Load Balancing

Cordinated Multi Point
±130ns Phase Accuracy
Higher Pick Date Rate
More Bandwidth
Better Load Balancing

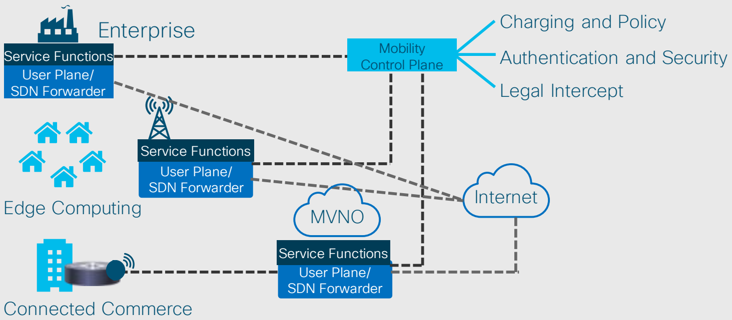
Platform Performance Requirements

T-BC Class	Max Time Error	Constant Time Error
A	±100ns	±50ns
B	±70ns	±20ns
C	±30ns	±5ns (P)

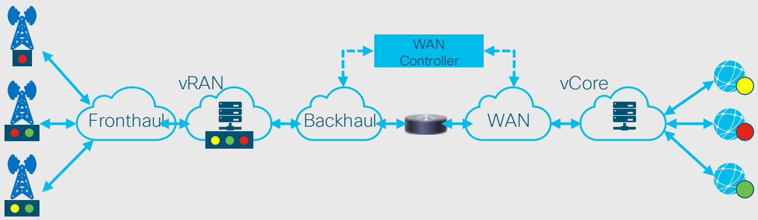
\+ **eEEC for improved SyncE**



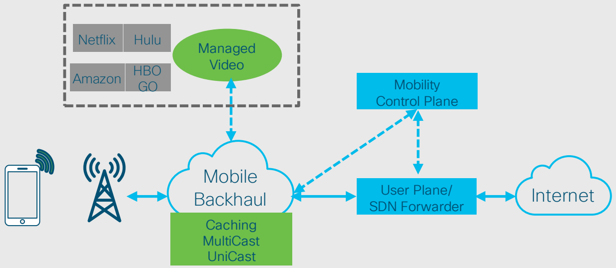
Key Enabling Technologies for 5G



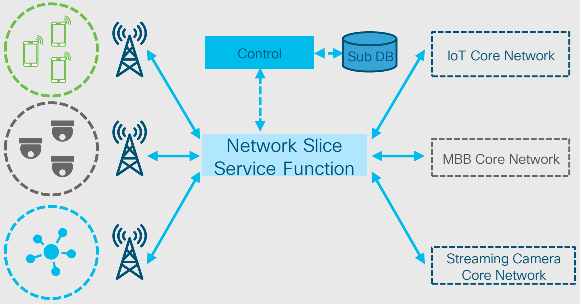
CUPS: Control/User Plane Separation



Cloud Scale Networking with Cloud RAN/Core and SD-WAN



Mobile network to scale with video using MEC



Network Slicing

Slicing according to 3GPP

A Network Slice is defined within a PLMN and shall include:

- the Core Network Control Plane and user plane Network Functions
- the NG Radio Access Network

Slice information is assigned to PDU session via NSSAI

NSSAI=up to 8x S-NSSAI

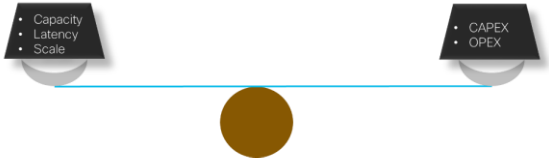
S-NSSAI=SST+SD (Slice/Service Type+ Slice Differentiator)

Slice/Service type	SST value
eMBB (enhanced Mobile Broadband)	1
URLLC (ultra- reliable low latency communications)	2
MIoT (massive IoT)	3

Slice in Transport Network Options

Separation	Network Elements	Link	IGP	Topology	QOS	Example
Full	Independent	Independent	Independent	Independent	Independent	WDM, dedicated routers
Logical Router	Shared	Independent	Partially dependent	Independent	Independent	WDM, SDR or VRF
Logical links Dedicated BW	Shared	Shared	Partially dependent	Independent	Independent	FlexE SDR or VRF
Logical links Shared BW	Shared	Shared	Partially dependent	Independent	shared	VLAN +QOS SDR or VRF
Shared Links	Shared	Shared	dependent	Independent	shared	MPLS+QOS TE or SRv6

5G Transport Requirements



- 1-10/25G Gbps connection to the end devices (RRU, eNB)
- 100 us ~ 10 ms end-to-end latency
- 10-100x number of connected devices
- Nanosecond accuracy through packetized timing
- 99.999% availability
- 100% coverage
- Services aware
- End to end secured

- Cost:
  - CAPEX:$/bit; $/unit
  - OPEX: Deployment, Management, Troubleshoot

Fronthaul Evolution

Fronthaul Today (2019)

Fronthaul: Transport between functional blocks (e.g., baseband processing & radio frequency blocks) of a cellular base station
Market: Fierce competition, consumer demand = ↑ Capacity
LTE rollout for coverage is largely completed, now:

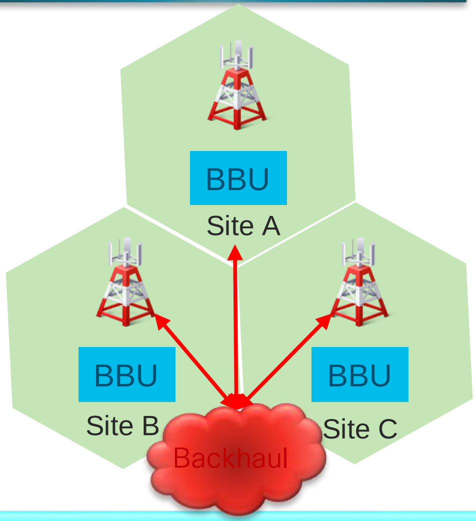
Adding capacity to 4G N/W with LTE-A, Small Cells, ↑ density, CA, MIMO
Preparing for 5G

Increasingly "C-RAN" (Centralized RAN) based

Lots of advantages (radio units close to each other)
But creates need for high capacity and low latency fronthaul network

C-RAN to Cloud RAN?

Traditional D-RAN

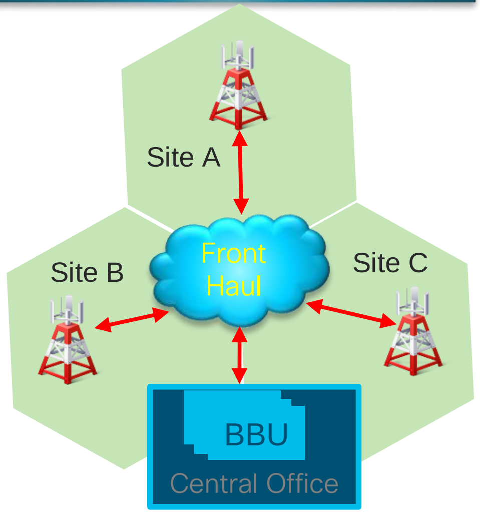


BBU co-located with RRU

Dedicated BBUs

Challenging for CoMP

Phase 1: C-RAN



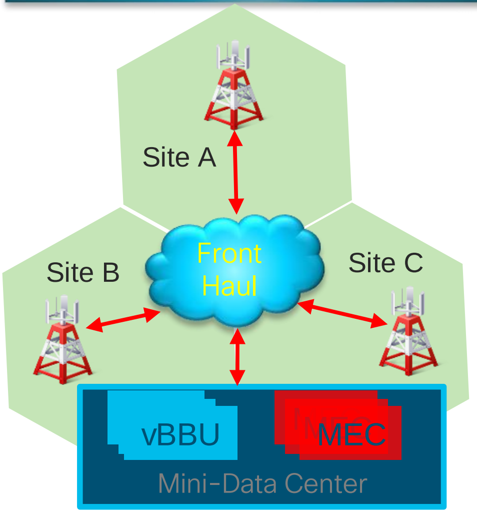
Centralized baseband units with potential for pooled baseband

CPRI interconnect
~2.4 Gbps/ 20 MHz channel

Enables CoMP and other LTE-A

Not virtualized

Phase 2: Cloud-RAN



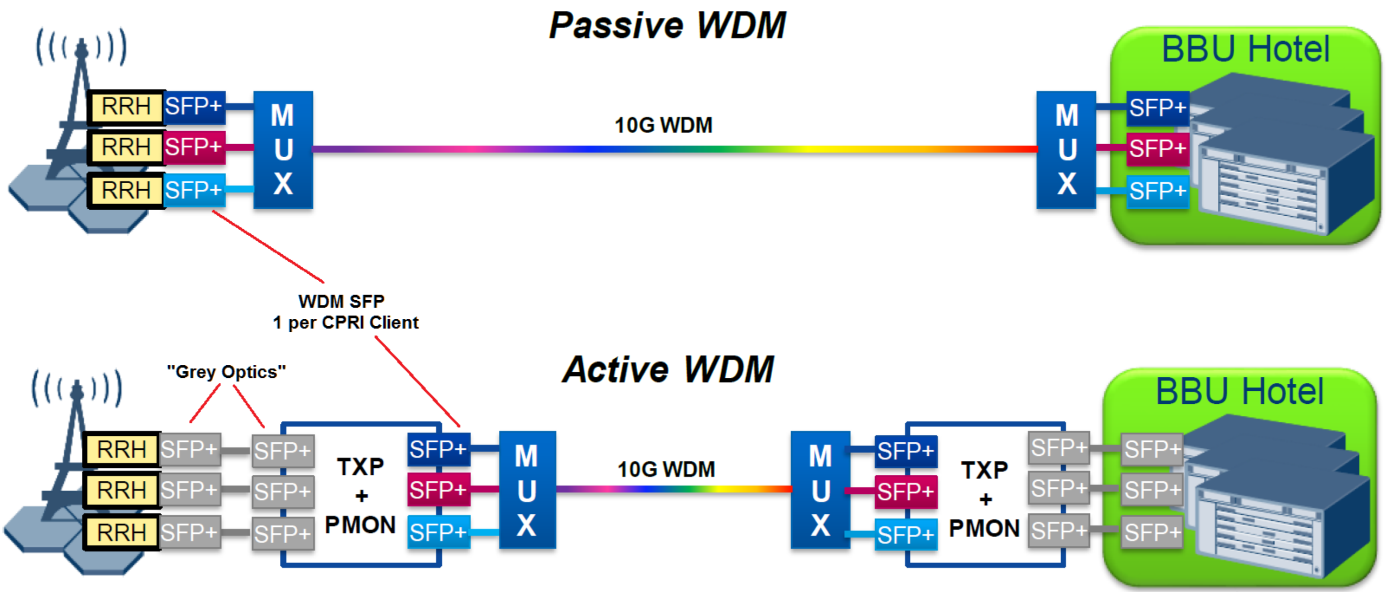
Virtualized baseband with RRC connection state shared across BS

CPRI over Ethernet or
NGFI Radio over Ethernet (future)

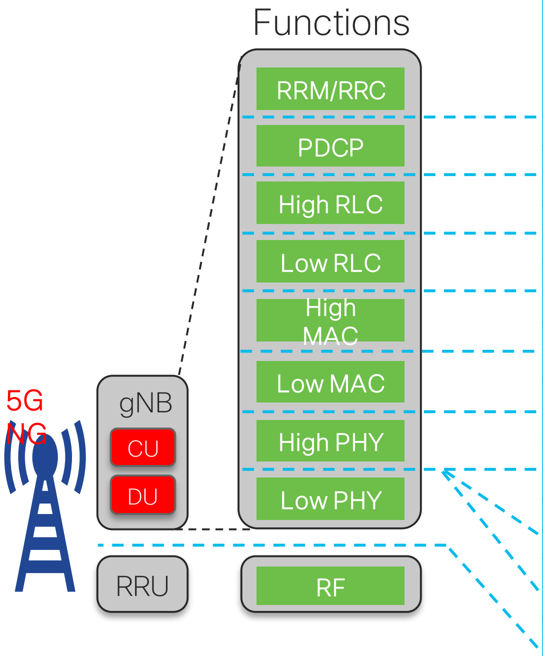
New functional split

Service Integration (MEC)

Fronthaul Transport Today



5G Front-haul
RAN Functional Split Consideration



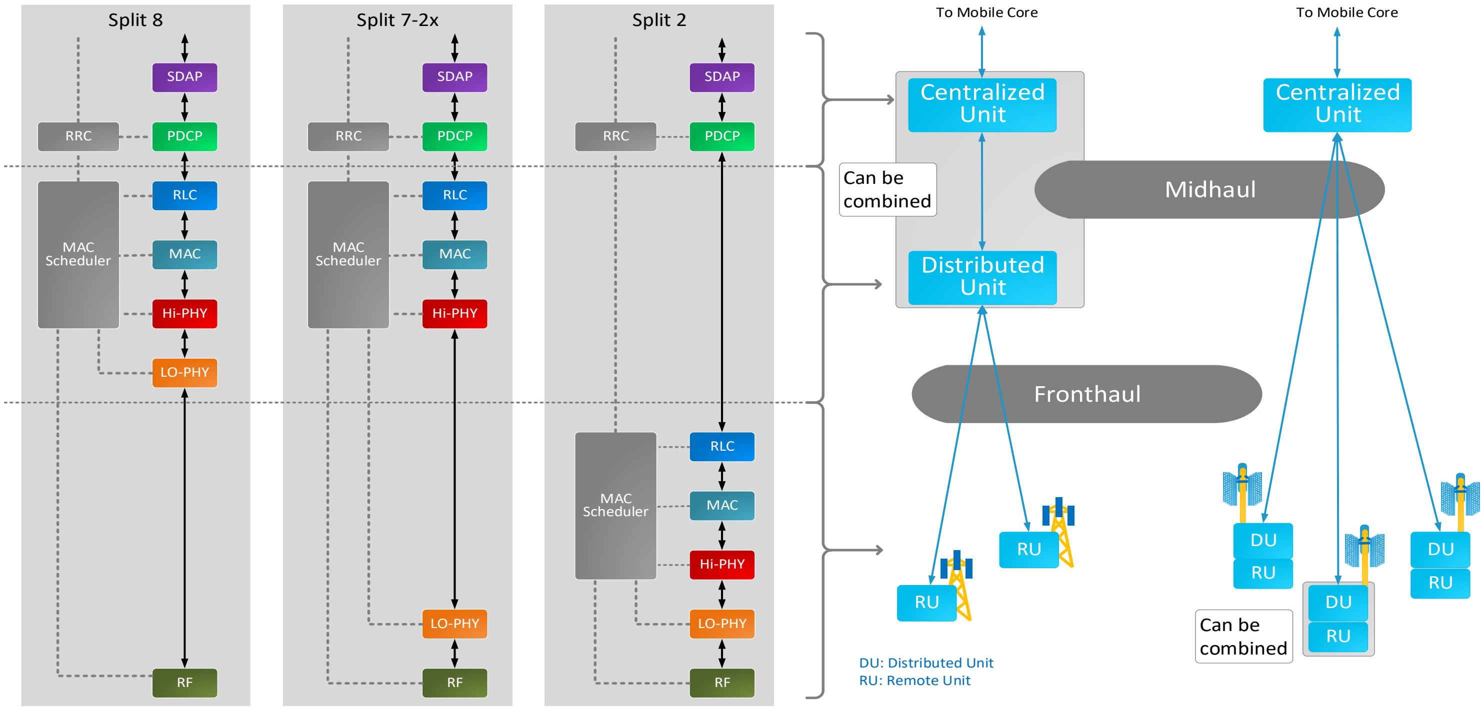
Split Option	Required Bandwidth		Max allowed 1-way Latency	Advanced RF Combining Capabilities
	DL	UL		
Option 1	4Gbps	3Gbps	10ms	
Option 2	4016Mbps	3024Mbps	1.5ms~10ms	CS/CB UL/DL
Option 3	Lower than option 2 for UL/DL		1.5ms~10ms	
Option 4	4000Mbps	3000Mbps	Approx 100us	
Option 5	4000Mbps	3000Mbps	100's us	+ CA, JP-DPS
Option 6	4133Mbps	5640Mbps	250us	+ JT (non-Coherent) + JR independent PHY decode
Option 7a	10.1~22.2Gbps	16.6~21.6Gbps	250us	
Option 7b	37.8~86.1Gbps	53.8~86.1Gbps	250us	+ JT (Coherent) + JR equalization PHY decode + High-order MIMO
Option 7c	10.1~22.2Gbps	53.8~86.1Gbps	250us	
Option 8	157.3Gbps	157.3Gbps	250us	

Transport costs minimized with higher splits

RF Gains improved with lower splits

Note: * Transmission link Requirements per TR 38.801 (100MHz, 256QAM,m 8x8 MIMO)

Functional Splits Mapped to C-RAN Functions

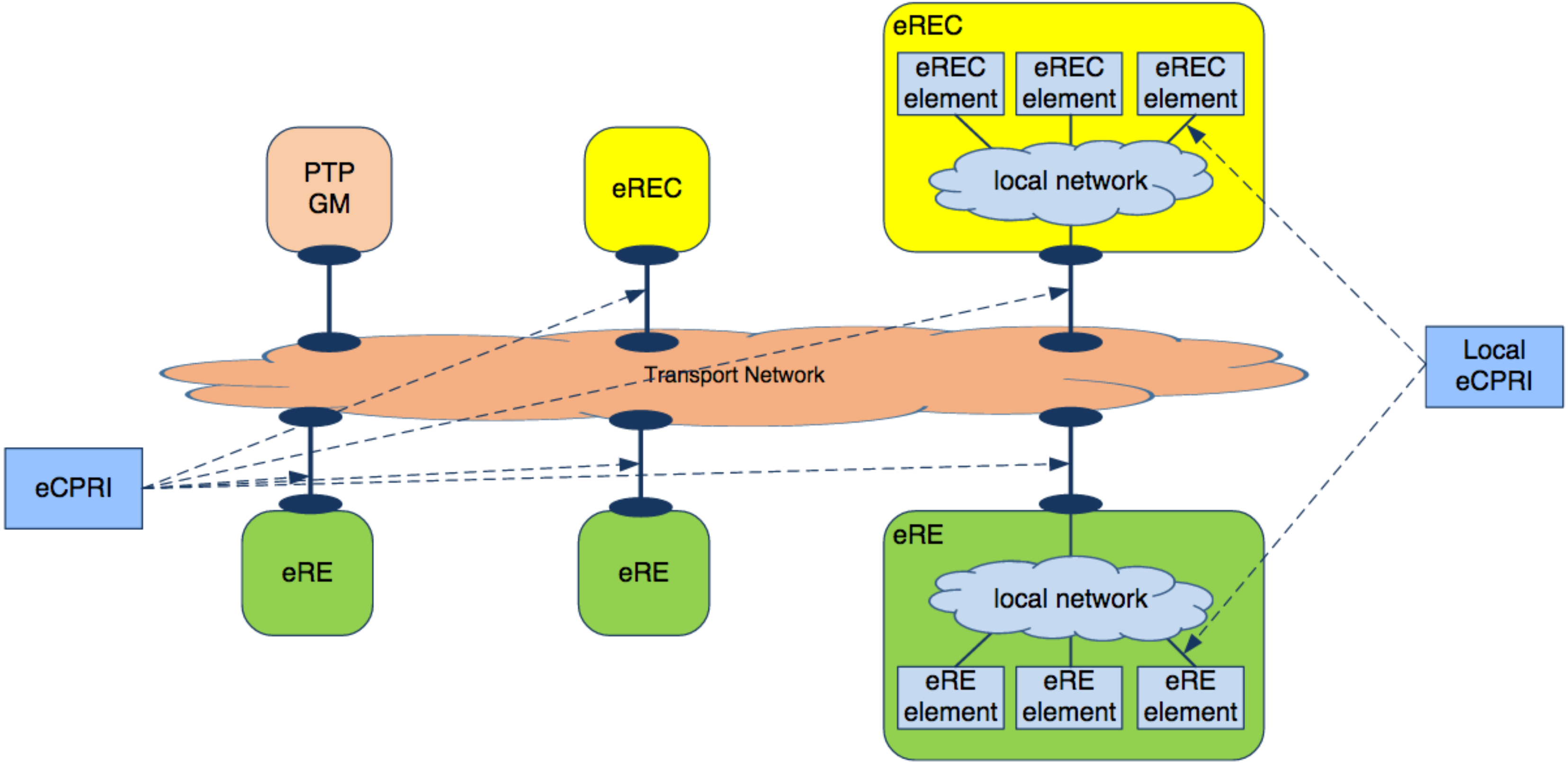


We see three basic RAN Splits that will ultimately determine the IP Transport Architecture

Ethernet Fronthalul Standardization

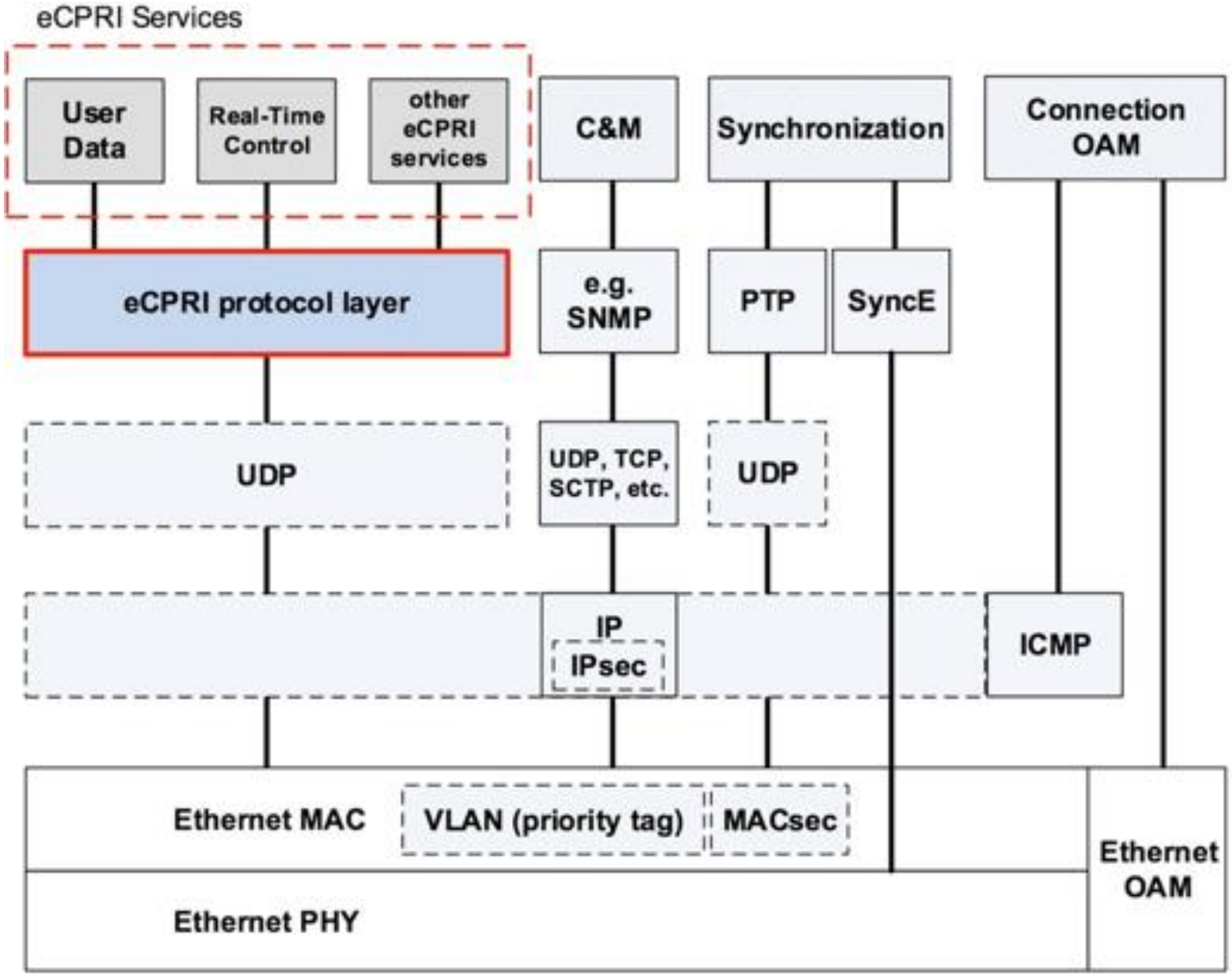
- CPRI 1.0 – 7.0 (2015)
- OBSAI 1.0 -2.0 (2006)
- ----------
- eCPRI 1.0, 1.1, 1.2 (Ericsson, Huawei, NEC, Nokia)
- xRAN 1.0-2.0 (ATT, Verizon, Cisco, DT, Maveneer, Nokia….) eCPRI encapsulation
- oRAN =OpenRAN+xRAN (ATT, China Mobile, DT Nokia …..) uses xRAN as baseline

eCPRI



PTP
GM
eREC
eREC
eREC
element
eREC
element
eREC
element
local network
Transport Network
eCPRI
Local
eCPRI
eRE
eRE
eRE
local network
eRE
element
eRE
element
eRE
element

eCPRI



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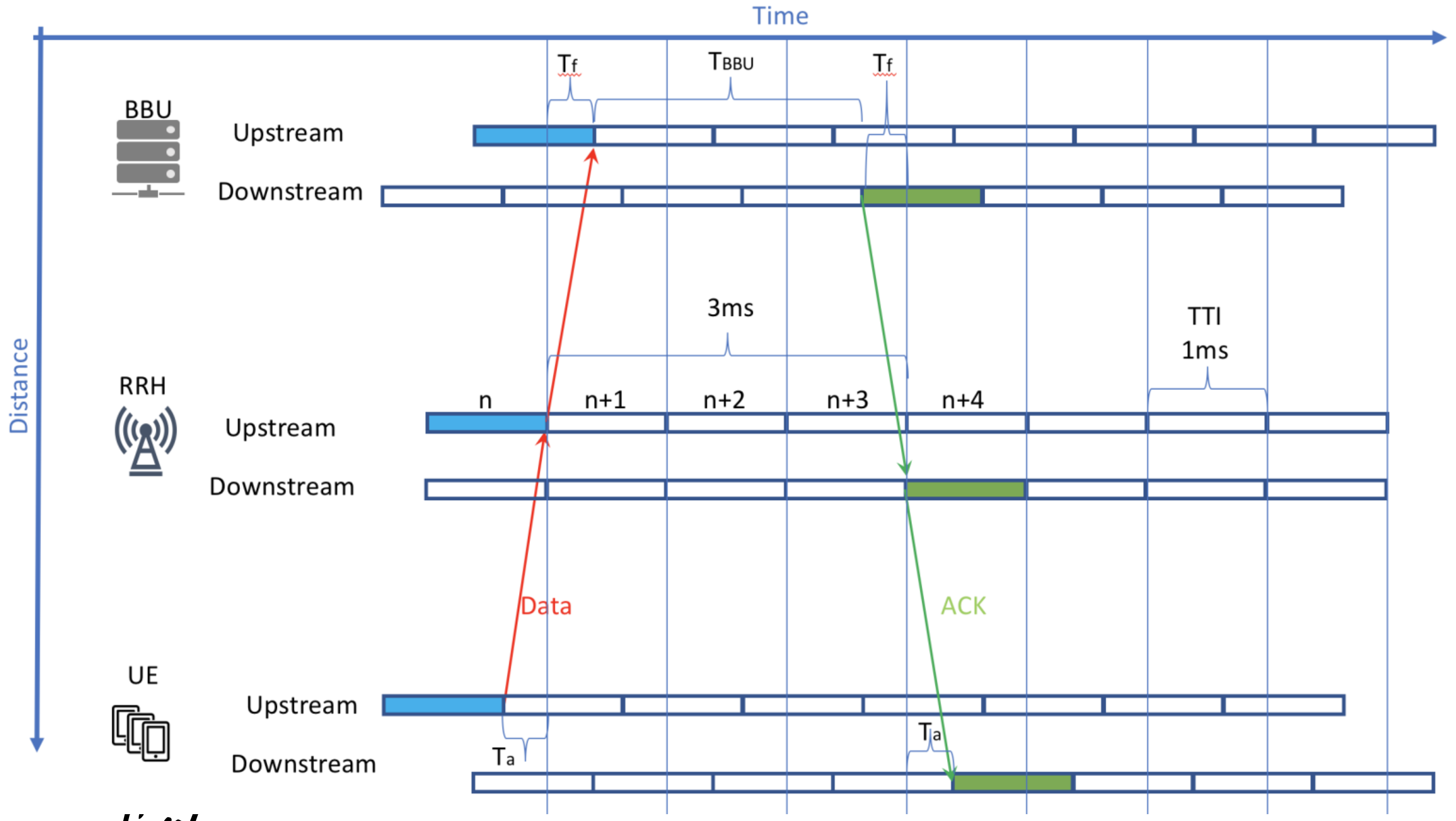
Latency Requirement



Fronthaul Over Non Ideal Transport

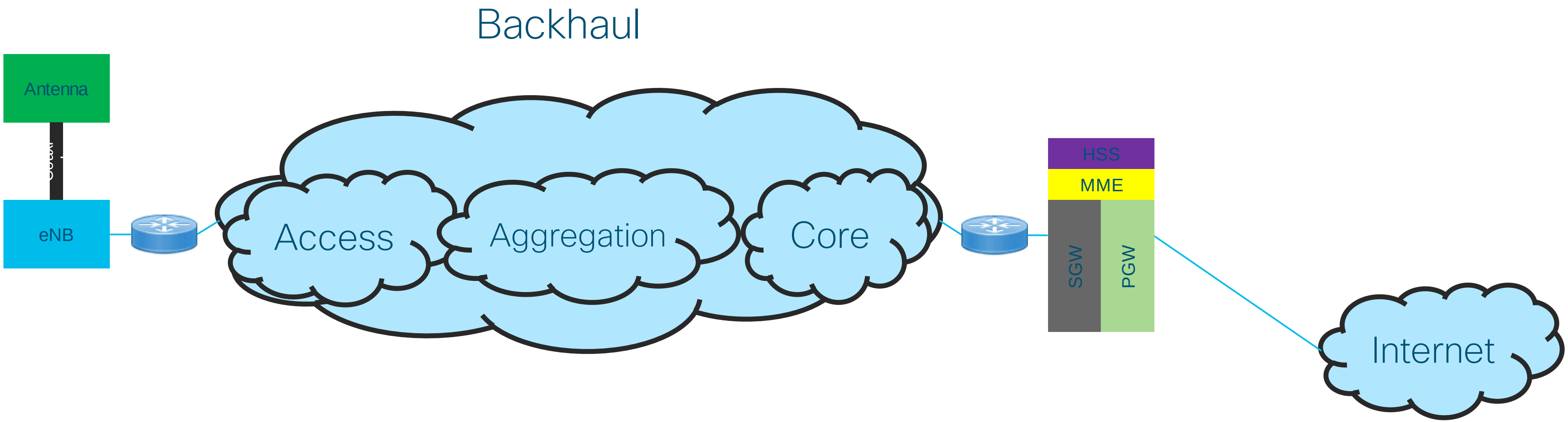
- Fronthaul over
  - Cable?
  - PON
  - G.fast
  - Microwave
- TIP (Telecomunication Infra Project)
- oRAN

Latency

Ultra Reliable and Low Latency Requirements

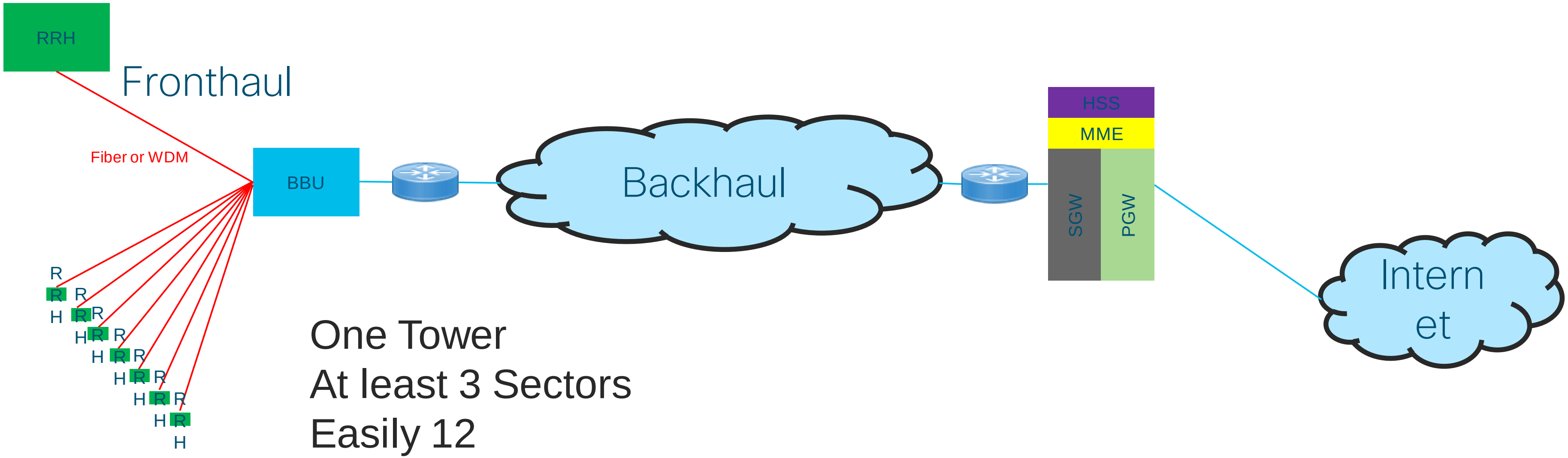
- 3GPP Defines latency and jiter requirements for different services
- Process automation Monitoring: 50ms
- Electricity distribution: 25ms -5ms (Low/High Voltage)
- Inteligent Transport Systems: 10 ms
- Remote Control:5ms
- Discrete automation motion control: 1ms
- Tactile interaction: 0,5 ms

Current State 4G



Mobile Network Evolution Fronthaul

CRAN- Centralized Radio Access Ne



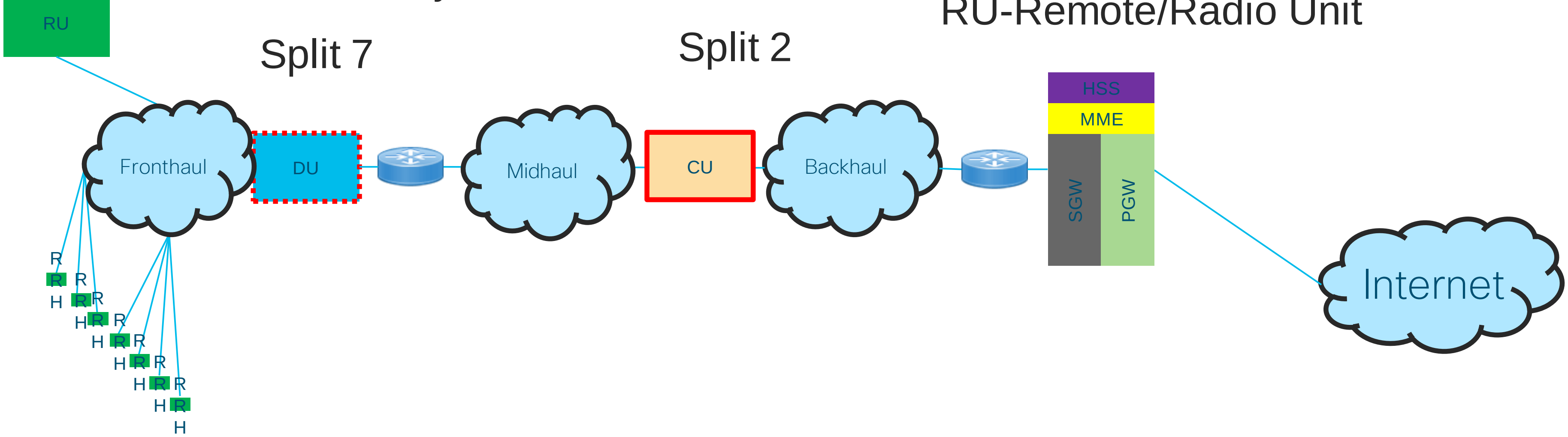
One Tower
At least 3 Sectors
Easily 12
MIMO

Mobile Network Evolution

Virtualized

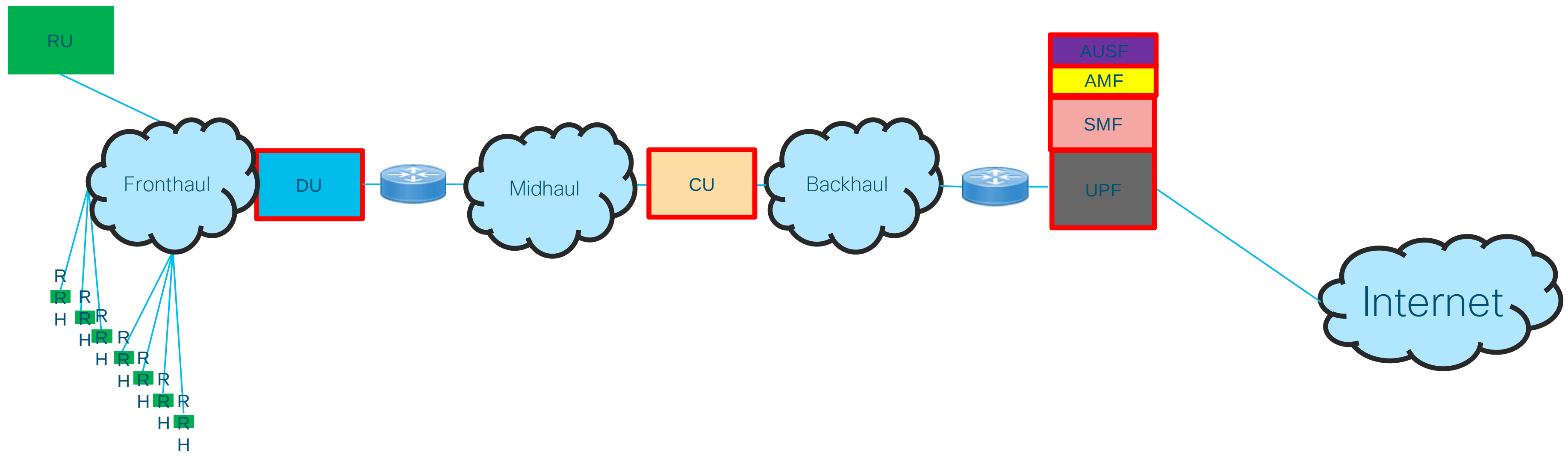
Latency!!!!!
Reason is HARQ loop
100-250us one way

CU-Centralized/Control Unit
DU-Distributed/Digital Unit (future vir
CU+DU=vBBU
RU-Remote/Radio Unit



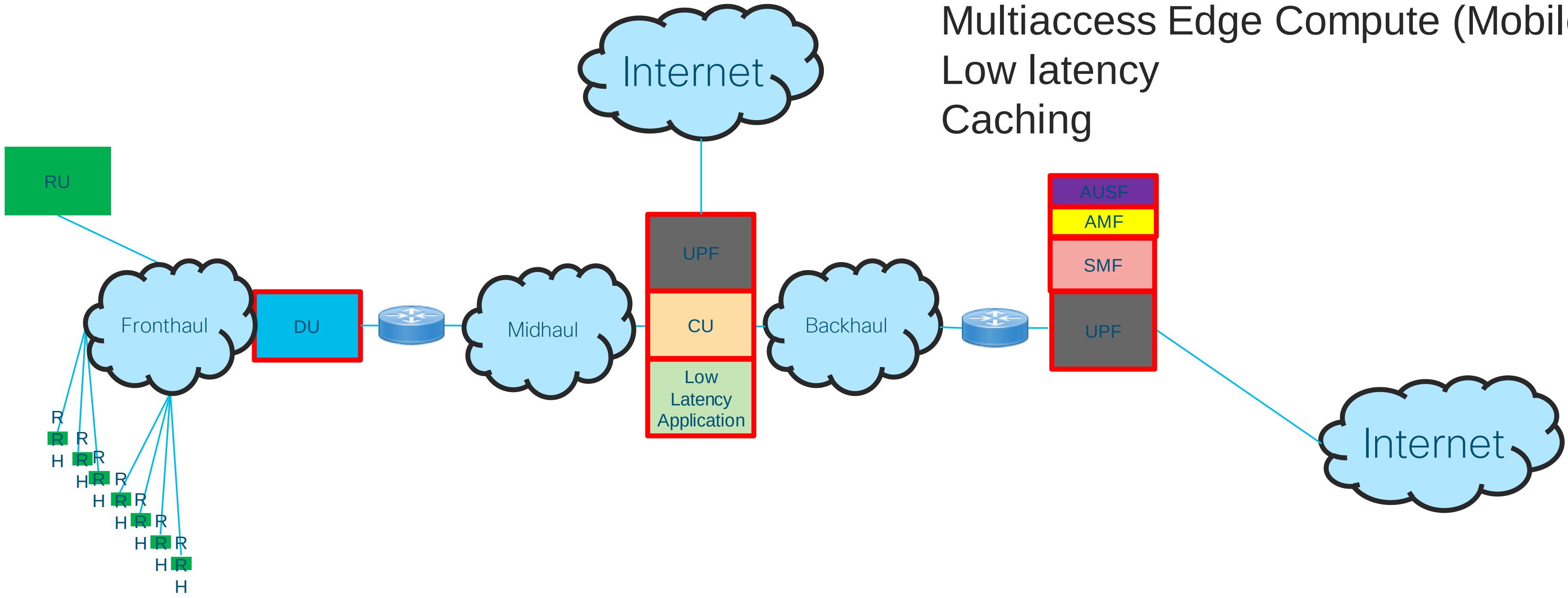
Mobile Network Evolution

AMF-Access and Mobility Management Function
SMF-Session Management Function
UPF-User Plane F…
AUSF-Autentication Server F…(HSS subset)



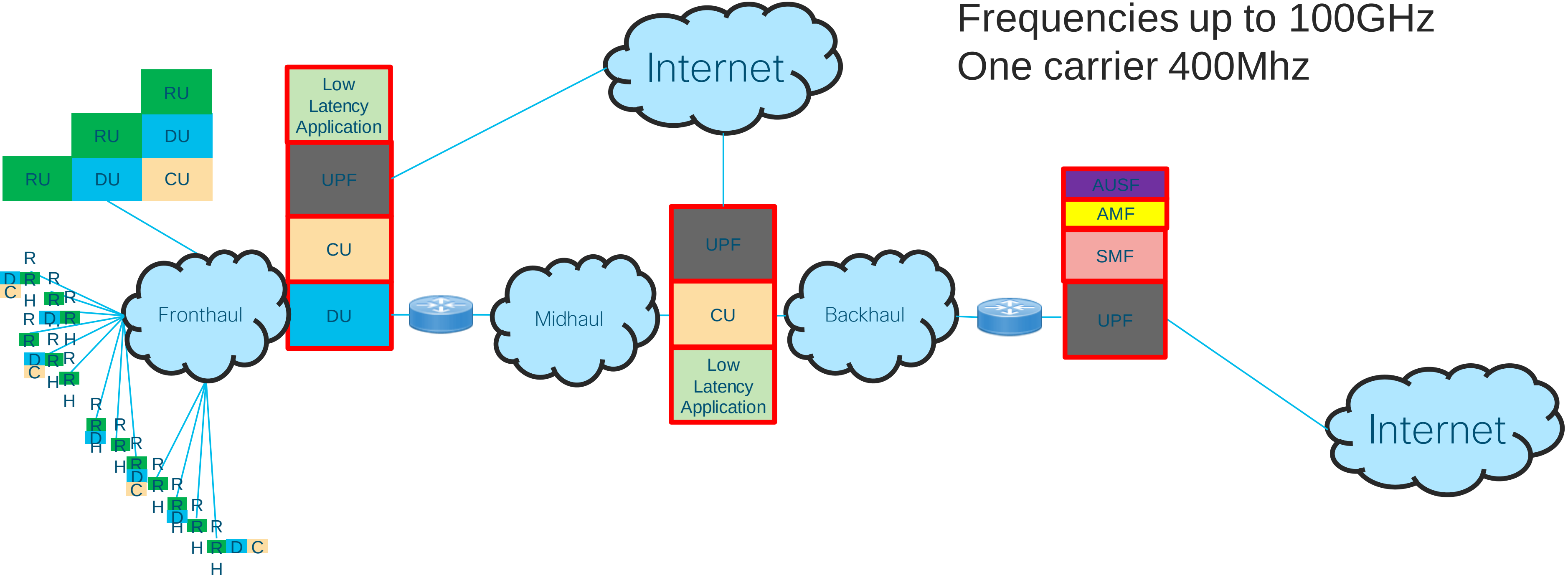
Mobile Network Evolution- MEC

Multiaccess Edge Compute (Mobile)
Low latency
Caching

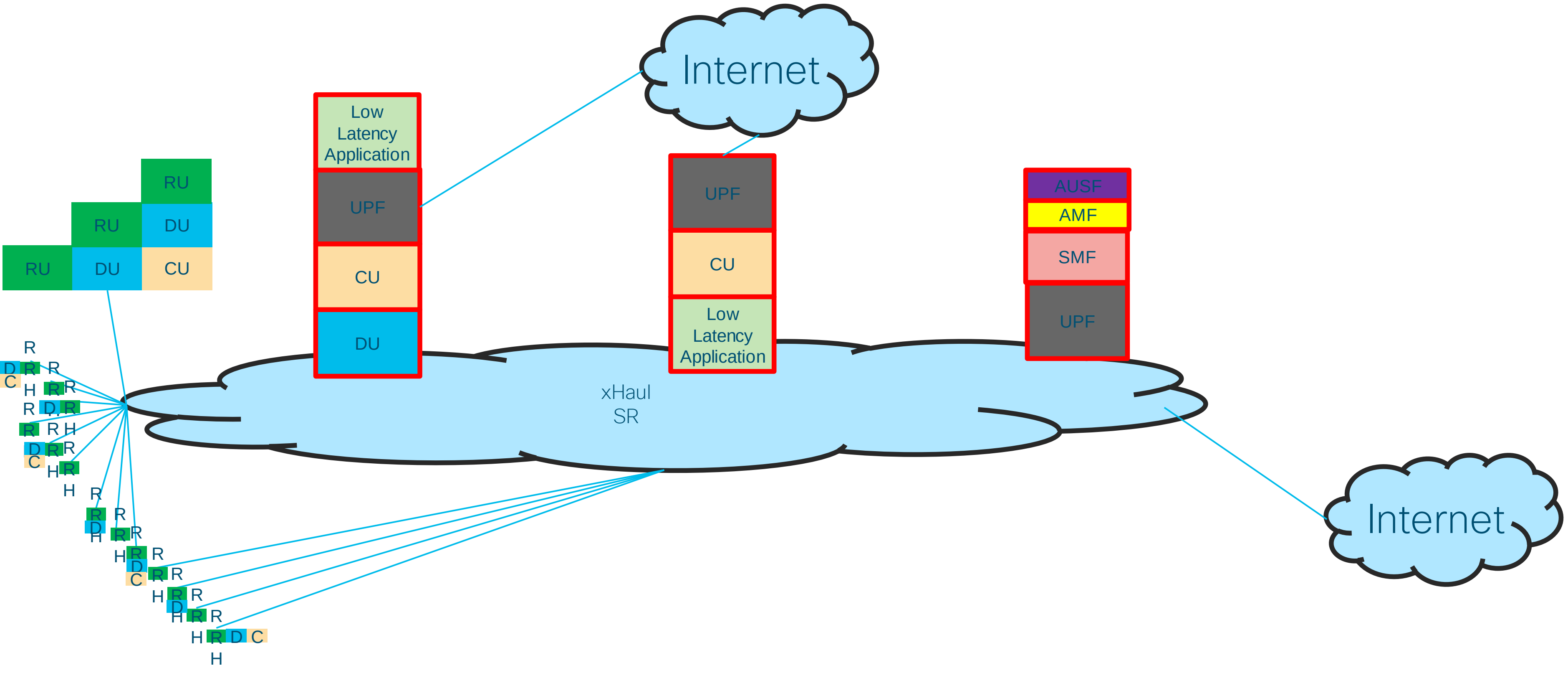


Mobile Network Evolution- Radio mmW

Frequencies up to 100GHz
One carrier 400Mhz



Mobile Network Evolution-

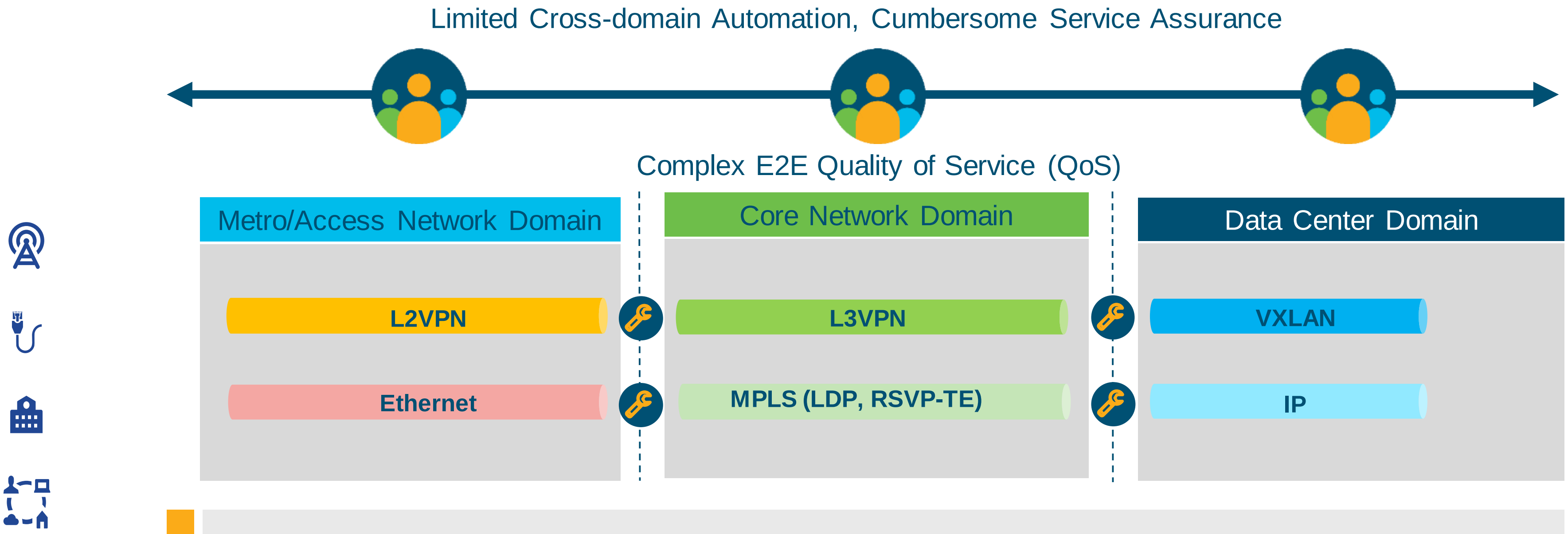


5G Needs from Transport

- ❑ Bandwidth (efficient usage)
- ❑ Latency awareness
- ❑ Network Slicing
- ❑ Reliability
- ❑ Simplicity = Programmability

Segment Routing

Problem statement: Today's service creation



End-to-end service provisioning is lengthy and complex

- Routing protocols are blind to applications (Shortest-path for any traffic)
- Multiple network domains under different management teams
- Manual operations
- Heterogeneous underlay and overlay networks

Segment Routing: Value Proposition

Create New Revenue Streams
- Differentiate Services with SR Policies
- Statelessly Chain Value-Add Services (no added protocols)

Deploy with Ease
- Seamless Brownfield Integration
- Single Control for Inter Domain Implementations

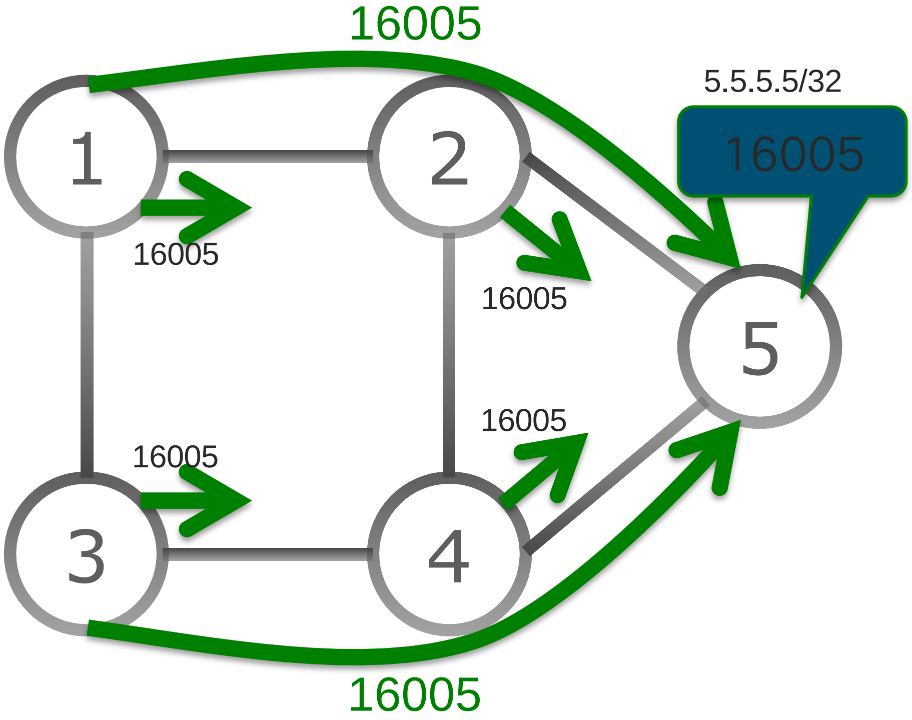
Monitor Health
- Data Path Validation Including ECMP
- Real Time Per-Link Performance Monitoring with Telemetry

Increase Availability
- Automated 50ms Protection
- Assured Loopfree Convergence upon Recovery

Multi-vendor consensus – Designed and built with network operators

IGP Prefix Segment

- Shortest-path to the IGP prefix
  - Equal Cost MultiPath (ECMP)-aware
- Global Segment
- Label = 16000 + Index
  - Advertised as index
- Distributed by ISIS/OSPF



All nodes use default SRGB
16,000 – 23,999

IGP Prefix Segment

- Shortest-path to the IGP prefix
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- Global Segment
- Label = 16000 + Index
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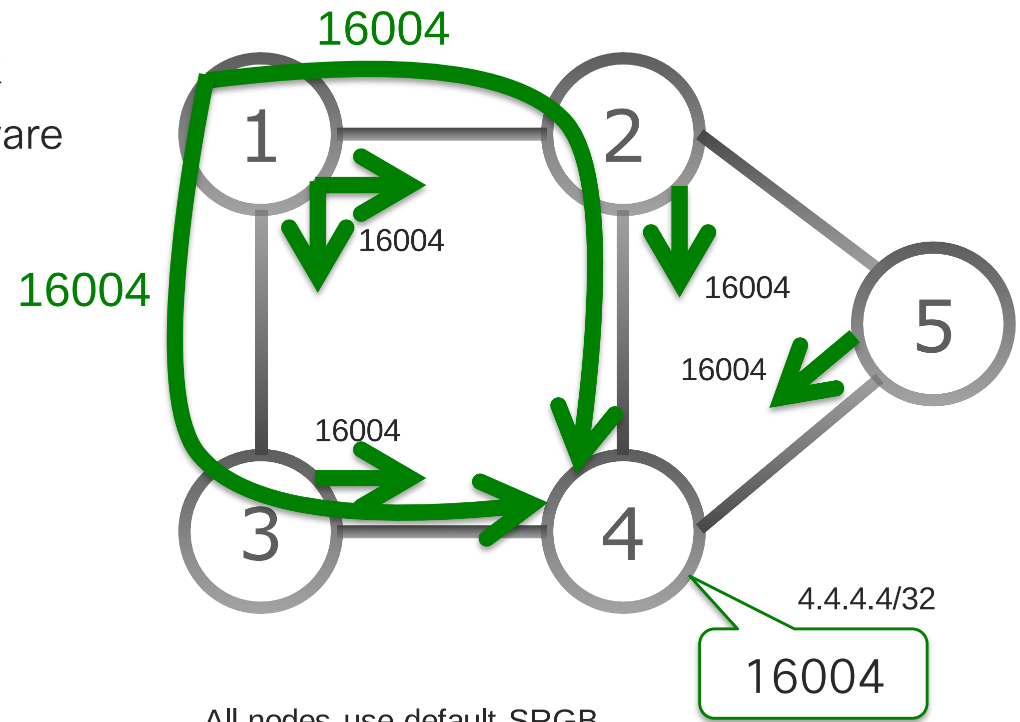
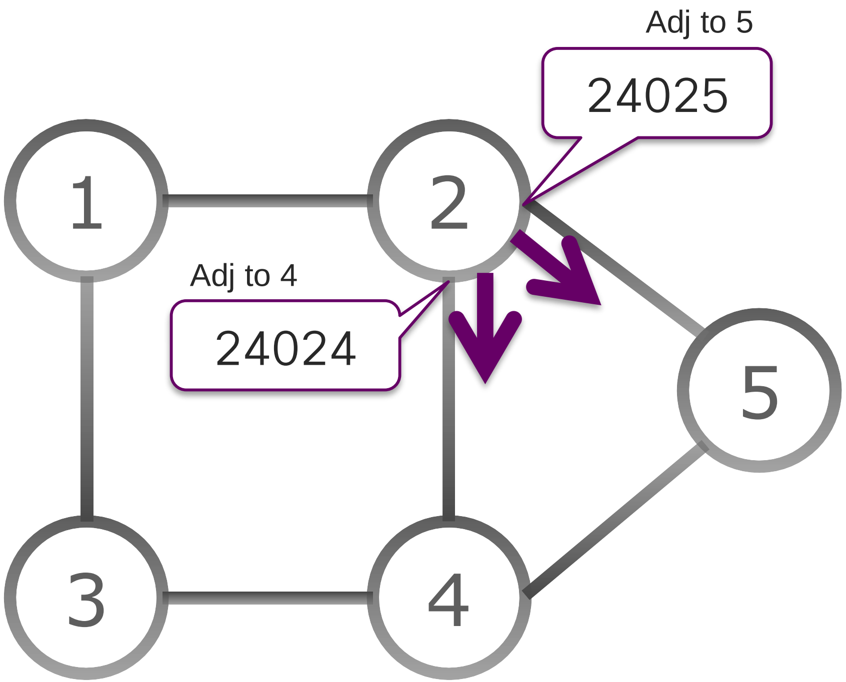


All nodes use default SRGB
16,000 – 23,999

IGP Adjacency Segment

- Forward on the IGP adjacency
- Local Segment
- Advertised as label value
- Distributed by ISIS/OSPF

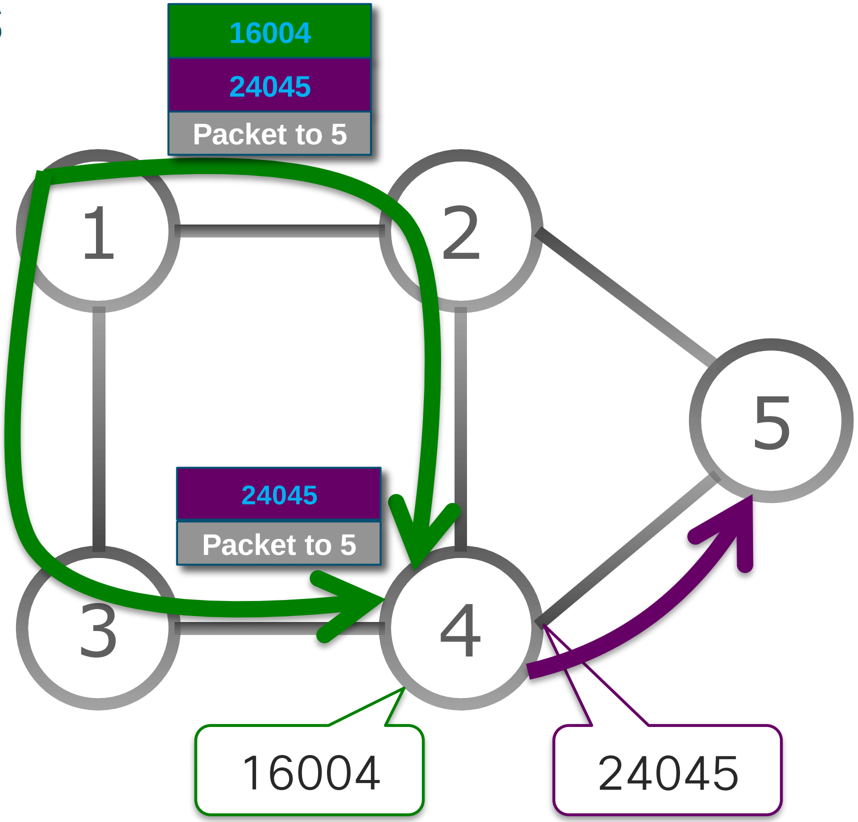


All nodes use default SRGB
16,000 – 23,999

Combining IGP Segments

All nodes use default SRGB
16,000 – 23,999

- Steer traffic on any path through the network
- Path is specified by list of segments in packet header, a stack of labels
- No path is signaled
- No per-flow state is created
- Single protocol: IS-IS or OSPF



Segment Routing – Forwarding Plane

- MPLS: an ordered list of segments is represented as a stack of labels
  - Segment Routing re-uses MPLS data plane without any change
  - Segment represented as MPLS label
  - Applicable to IPv4 and IPv6 address families
- IPv6: an ordered list of segments is encoded in a routing extension header

TI-LFA

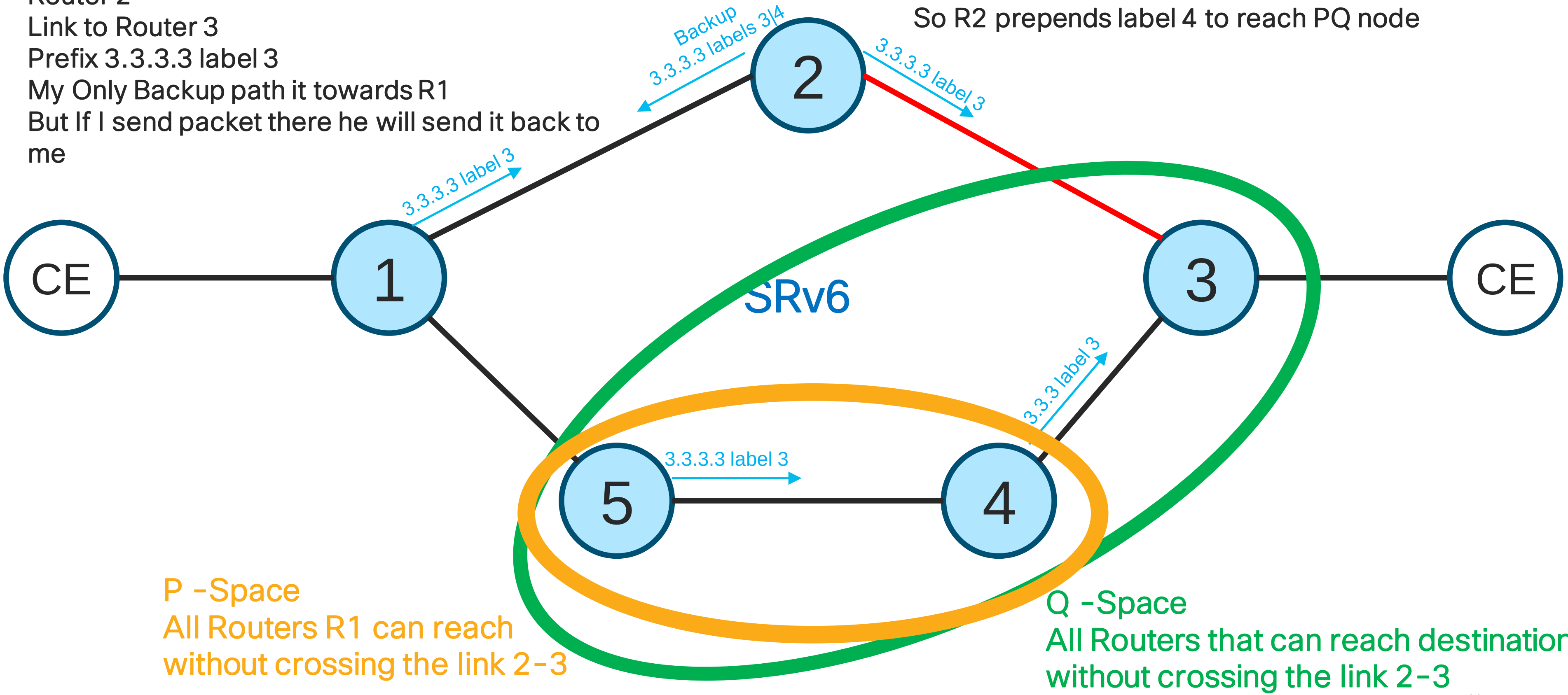
Topology Independent LFA (TI-LFA) – Benefits

- 100%-coverage 50-msec link and node protection
- Prevents transient congestion and suboptimal routing
  - leverages the post-convergence path, planned to carry the traffic
- Simple to operate and understand
  - automatically computed by the IGP
- Incremental deployment
  - also protects LDP and IP traffic

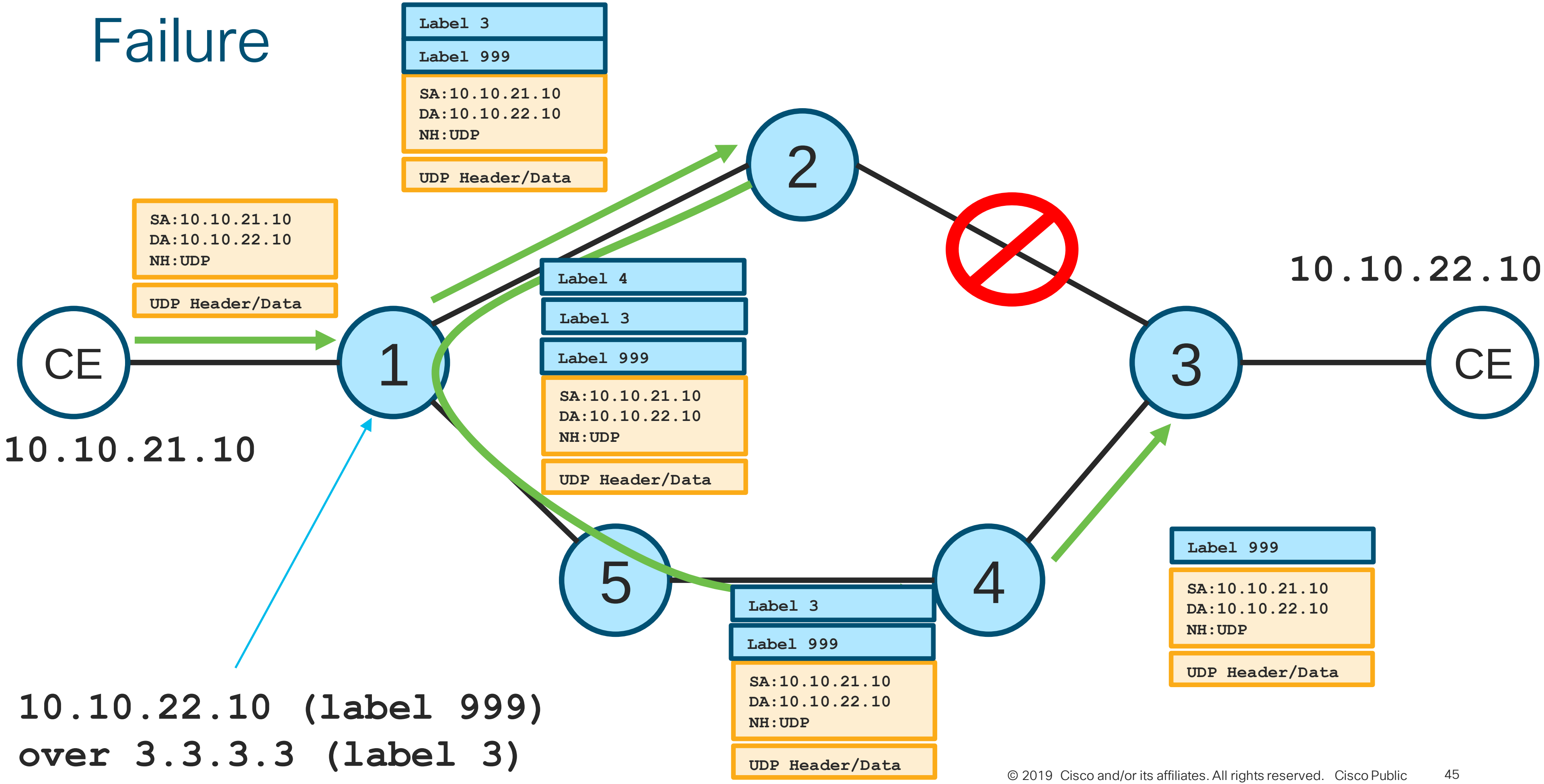
Calculating Backup Path

Router 2
Link to Router 3
Prefix 3.3.3.3 label 3
My Only Backup path it towards R1
But If I send packet there he will send it back to me

PQ nodes are 5 and 4
So 4 is selected
So R2 prepends label 4 to reach PQ node

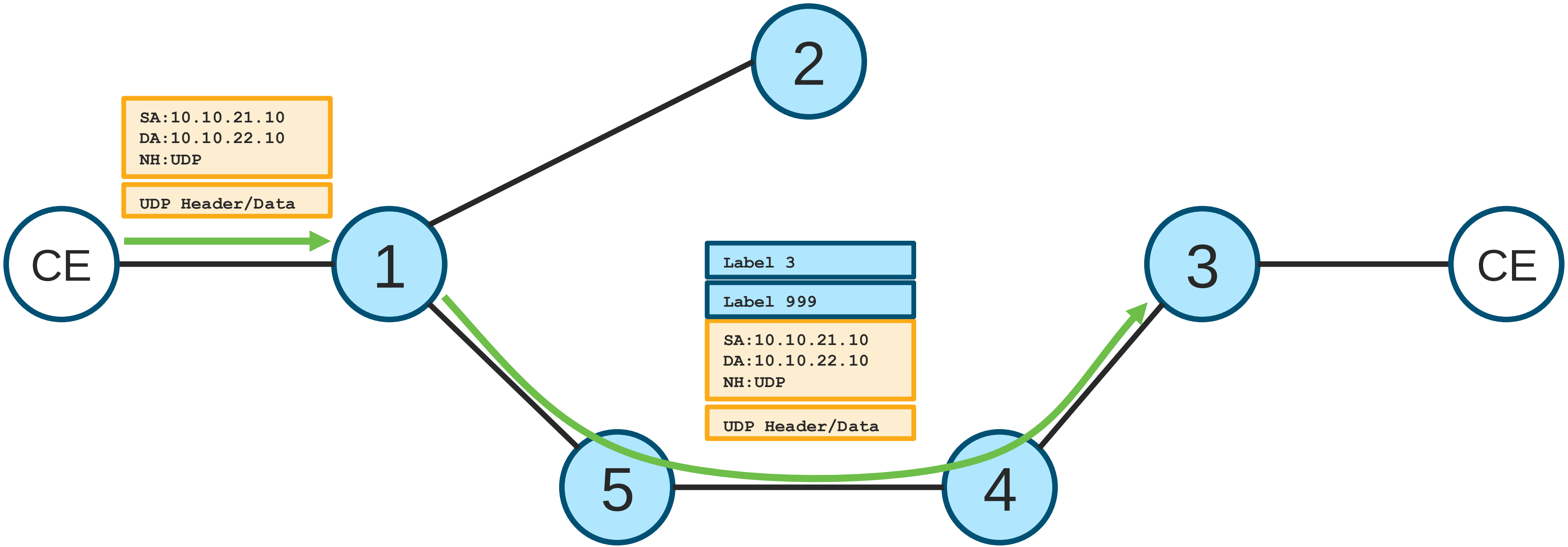


Failure



10.10.22.10 (label 999) over 3.3.3.3 (label 3)

Converged



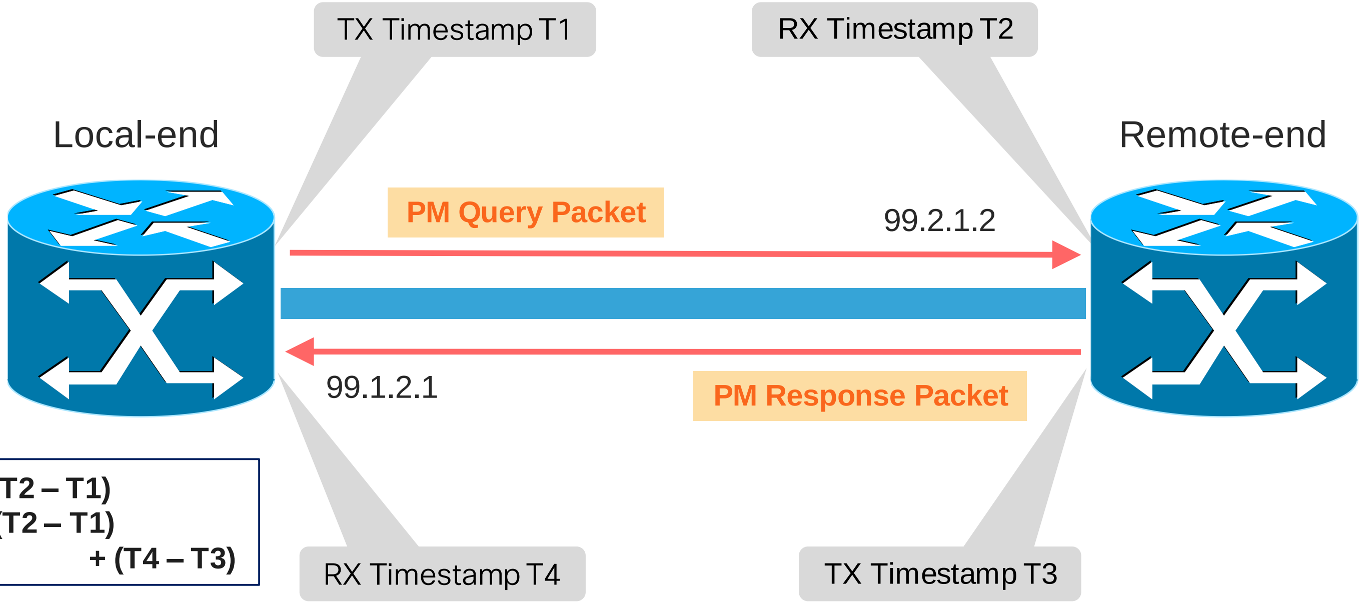
SA:10.10.21.10
DA:10.10.22.10
NH:UDP
UDP Header/Data
CE
1
2
Label 3
Label 999
SA:10.10.21.10
DA:10.10.22.10
NH:UDP
UDP Header/Data
3
CE
5
4

Performance Monitoring

Extended TE Link Delay Metrics

- Extended TE link delay metrics (average, minimum/maximum, variance values) allow operators to monitor their network latency performance automatically and can be used to provide Service Level Agreements, for troubleshooting, etc.
  - Operators can place SR Policies in the network that can provide the least amount of delay
  - Operators can ensure Customer traffic is not sent on SR Policies that exceed the specified accumulated delay bound

Link Delay Measurement Protocol



One Way Delay = (T2 – T1)
Two-Way Delay = (T2 – T1)
+ (T4 – T3)

PM Query and Response using RFC 6374 packet format

Standards used

- RFC 6374
- Supports MPLS encapsulation GAL
- Supports UDP encapsulation, port 6634

Flexible Algorithm

SR IGP Flex Algo

- Complements the SRTE solution by adding new Prefix-Segments with specific optimization objective and constraints
  - minimize igp-metric or delay or te-metric
  - avoid SRLG or affinity
- Leverages the SRTE benefits of simplicity and automation
  - Automated sub-50msec FRR (TILFA)
  - On-Demand Policy (ODN)
  - Automated Steering (AS)

Currently defined algorithms

- 0: Shortest Path First (SPF) algorithm based on link metric.
  - This is the well-known shortest path algorithm as computed by the IS-IS Decision process. Consistent with the deployed practice for link-state protocols, algorithm 0 permits any node to overwrite the SPF path with a different path based on local policy
- 1: Strict Shortest Path First (SPF) algorithm based on link metric.
  - The algorithm is identical to algorithm 0 but algorithm 1 requires that all nodes along the path will honor the SPF routing decision. Local policy MUST NOT alter the forwarding decision computed by algorithm 1 at the node claiming to support algorithm

Flexible Algorithm

- We call “Flex-Algo”
  - The algorithm is defined by the operator, on a per-deployment basis
- Flex-Algo K is defined as
  - The minimization of a specified metric: IGP, delay, …
  - The exclusion of certain link properties: link-affinity, SRLG, …
- Example
  - Operator1 defines Flex-Algo 128 as “minimize IGP metric and avoid link-affinity “green”
  - Operator2 defines Flex-Algo 128 as “minimize delay metric and avoid link-affinity “blue”

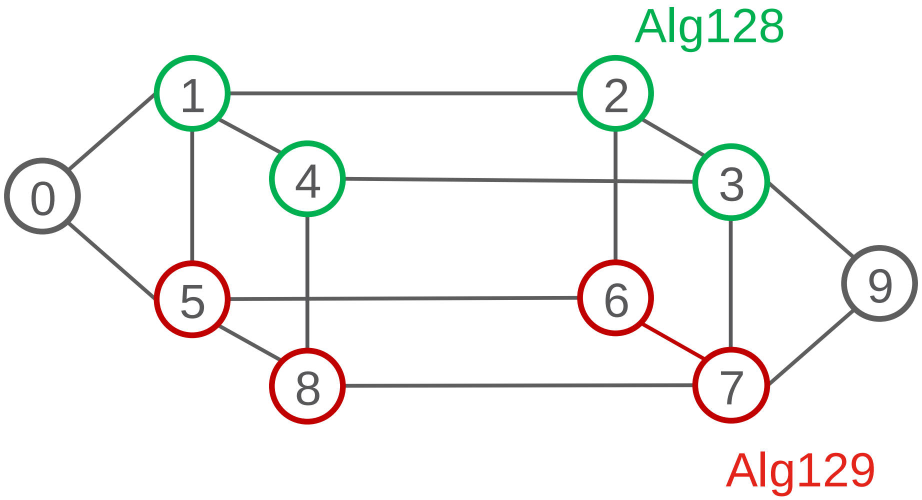
Flex-Algo Participation Advertisement

- Each node MUST advertise Flex-Algo(s) that it is participating in

Nodes 0 and 9 participate to Algo 0 and 128 and 129

Nodes 1/2/3/4 participate to Algo 0 and 128

Nodes 5/6/7/8 participate to Algo 0 and 129



Prefix-SID for each Flex-Algo

- If a node advertises participation in a Flex-Algo likely it also advertises a prefix SID for that Flex-Algo

Node 9 advertises

Prefix SID 16009 for ALGO 0

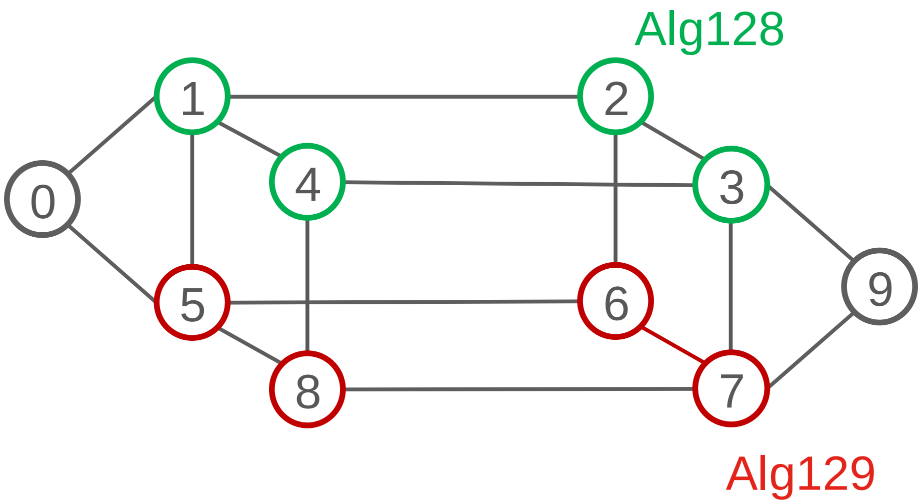
Prefix SID 16809 for ALGO 128

Prefix SID 16909 for ALGO 129

Node 2 advertises

Prefix SID 16002 for ALGO 0

Prefix SID 16802 for ALGO 128



No additional loopback address

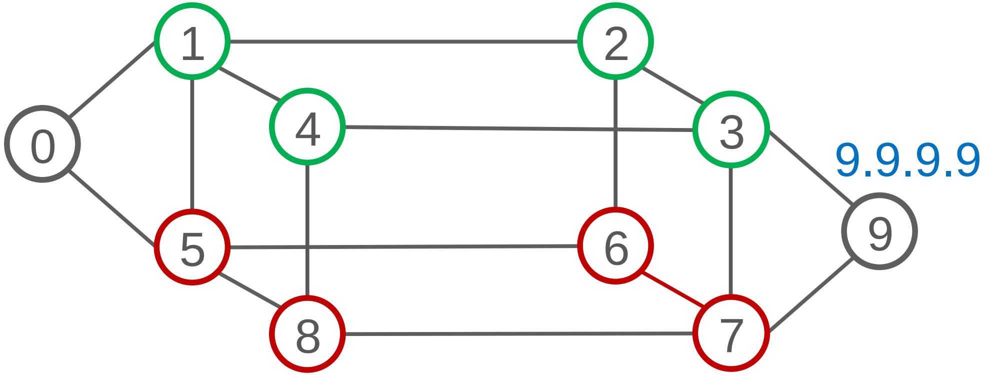
- Flex-Algo Prefix SID's can be advertised as additional prefix-SID's of the existing loopback address

Node 9 advertises loopback0 9.9.9.9/32 with

Prefix SID 16009 for ALGO 0

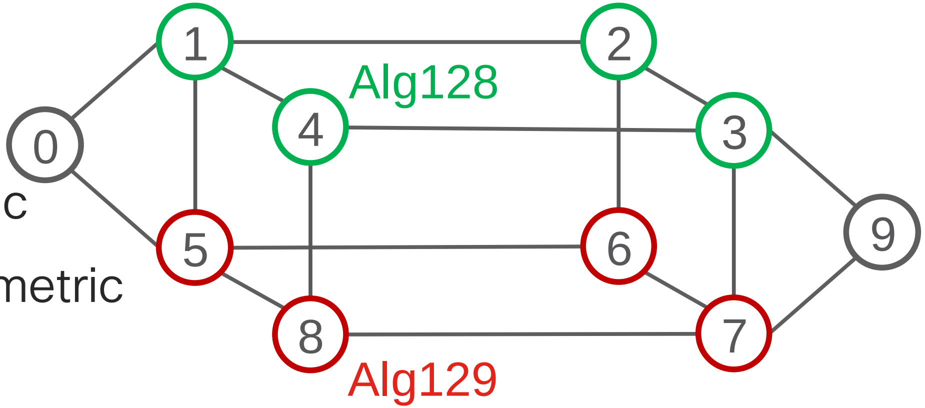
Prefix SID 16809 for ALGO 128

Prefix SID 16909 for ALGO 129



Example 1

- Grey nodes support Algo 0/128/129
- Green nodes support 0/128
- Red nodes support 0/129
- Algo 128: minimize IGP metric
- Algo 129: minimize Latency metric
- Nodes advertise a Prefix SID for each Algo they support
  - For example, for node N: 16000 + N
    - + 0 for Algo 0
    - + 800 for Algo 128
    - + 900 for Algo 129



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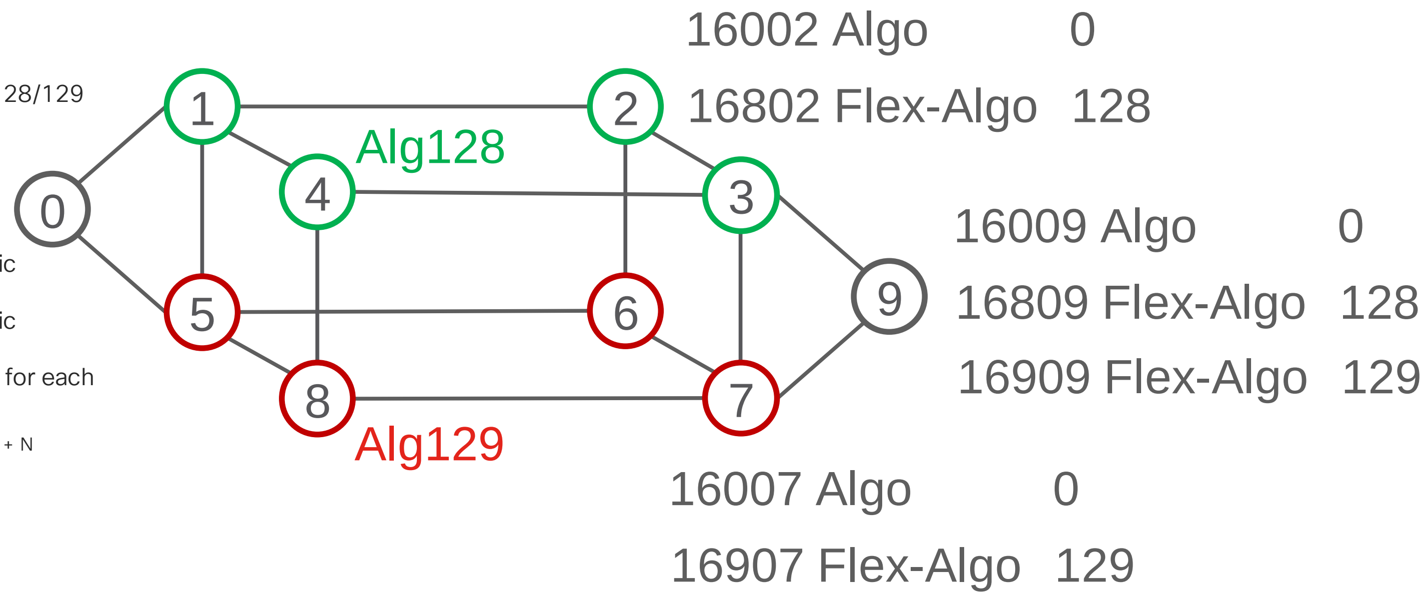
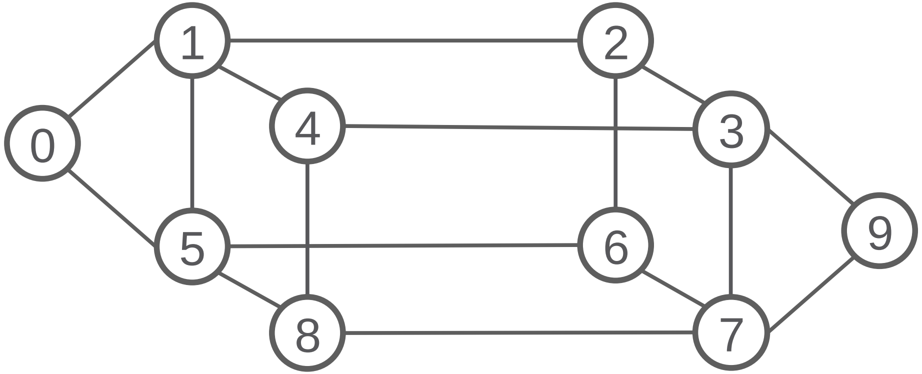


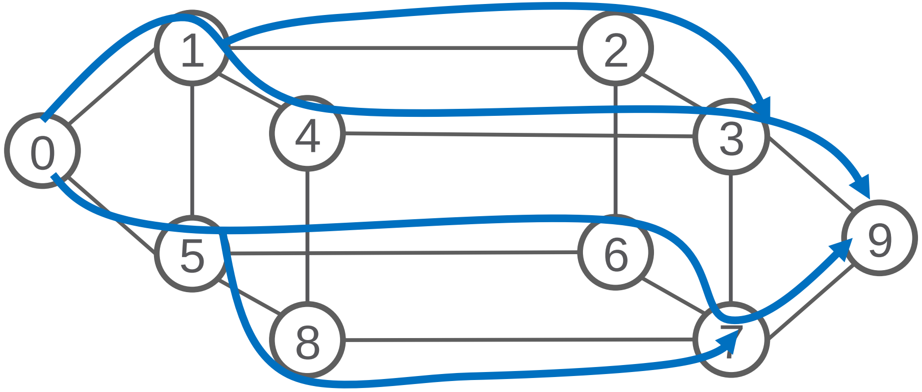
Example 1 – Topo(0)



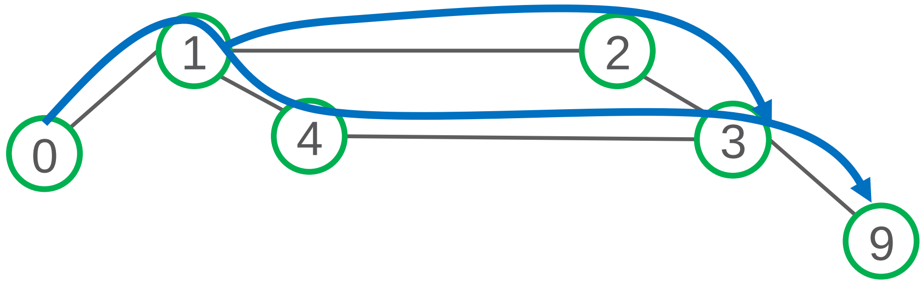
Example 1 – Topo(128)

Example 1 – Topo(129)

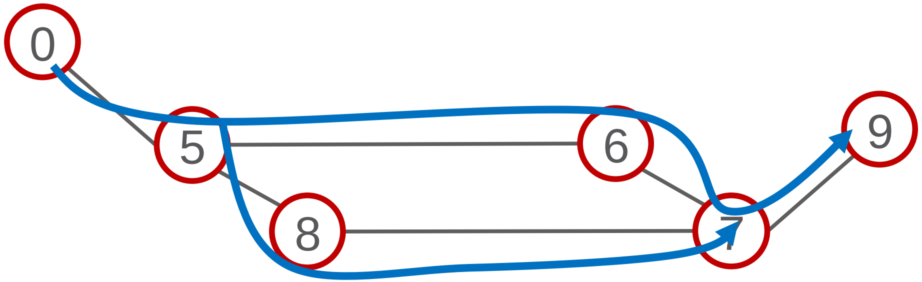
Example 1 – Prefix-SID 16009 of Algo 0



Example 1 – Prefix-SID 16809 of Flex-Algo 128



Example 1 - Prefix-SID 16909 of Flex-Algo 129



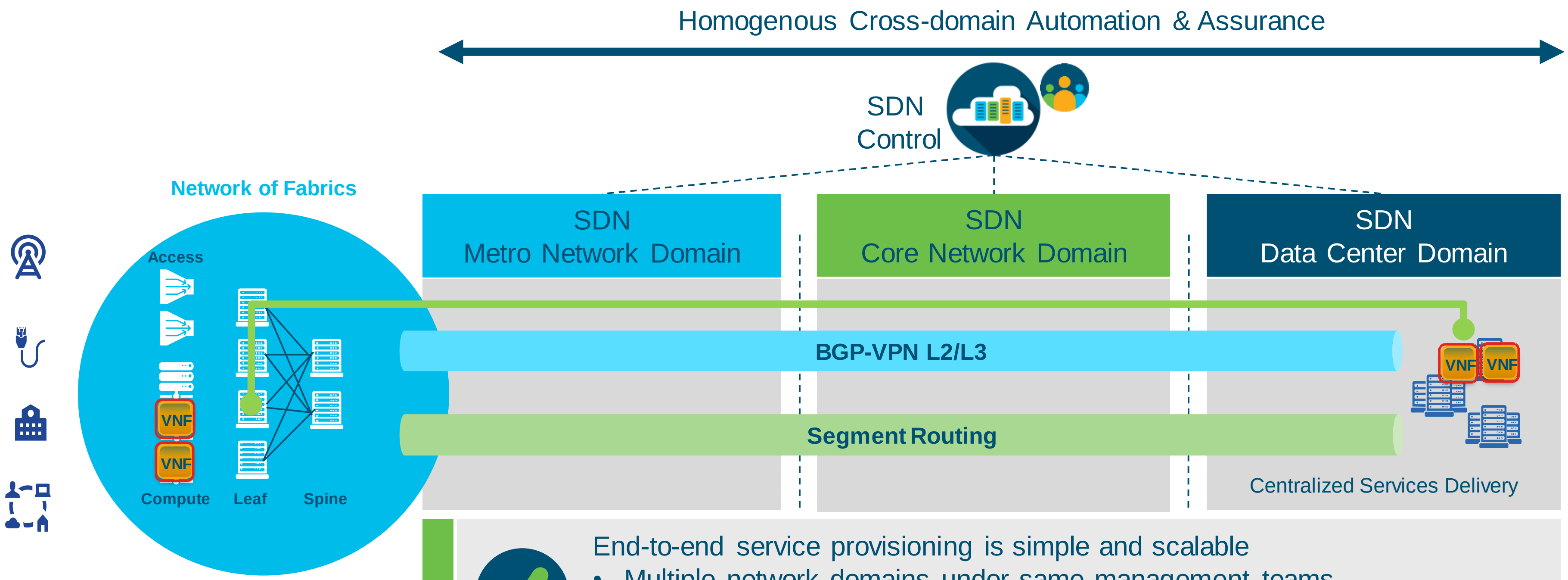
Conclusion

Cisco live!

5G Needs from Transport

- ☑ Bandwidth (efficient usage)
- ☑ Latency awareness
- ☑ Network Slicing
- ☑ Reliability
- ☑ Simplicity = Programmability

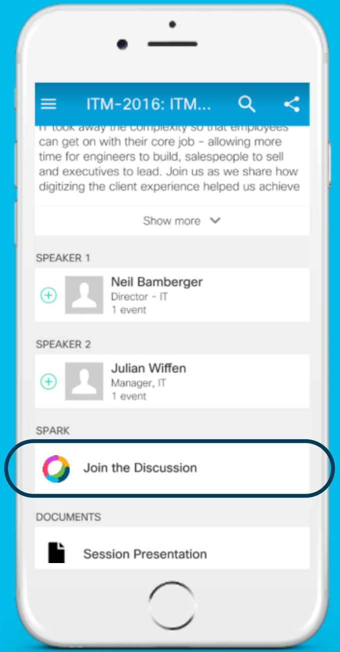
Segment Routing Unified Fabric vision



End-to-end service provisioning is simple and scalable

- Multiple network domains under same management teams
- Automated operations
- Homogenous underlay and overlay networks

Cisco Webex Teams



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Questions?

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How

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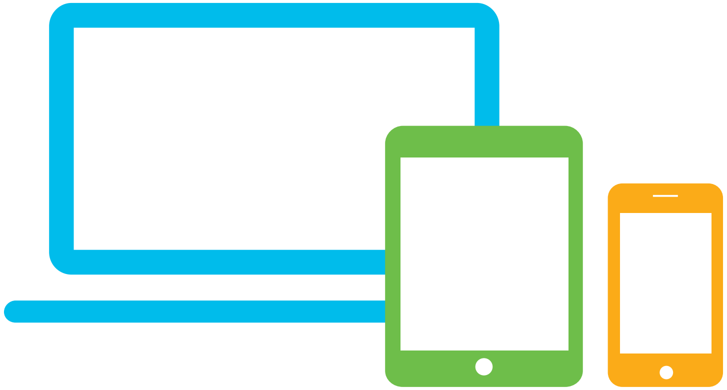
2. Click “Join the Discussion”
3. Install Webex Teams or go directly to the team space
4. Enter messages/questions in the team space

Complete your online session survey

- Please complete your Online Session Survey after each session
- Complete 4 Session Surveys & the Overall Conference Survey (available from Thursday) to receive your Cisco Live T-shirt
- All surveys can be completed via the Cisco Events Mobile App or the Communication Stations

Don't forget: Cisco Live sessions will be available for viewing on demand after the event at ciscolive.cisco.com



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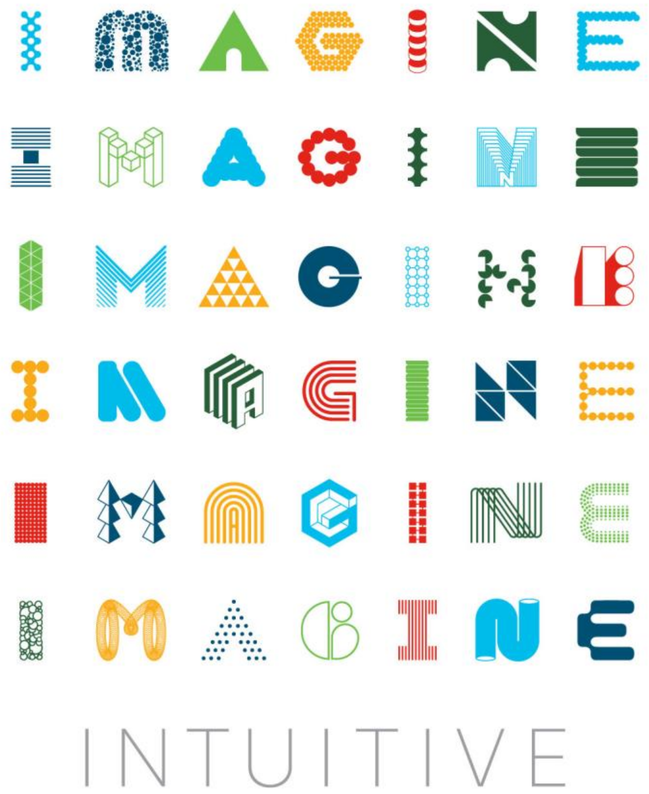
Thank you



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