



TURN
IT
UP

CISCO *Live!*

#CiscoLive



The bridge to possible

5G xHaul Transport

Design Considerations, Strategies and Best Practices

Kashif Islam (kislam@cisco.com)

5G Solutions Architect

@kuislam1

BRKSPG-2060



CISCO *Live!*

#CiscoLive



Agenda

- RAN Evolution Driving Mobile Backhaul Evolution
- Operator Defined xHaul Deployment Scenarios
- xHaul Design Consideration
- Summary

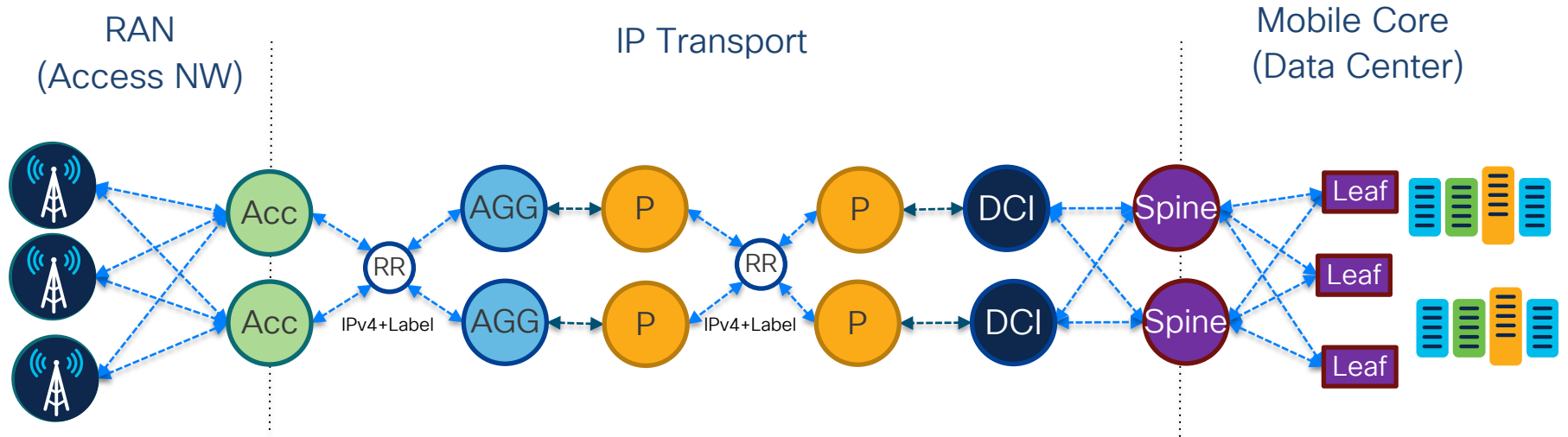
RAN/xHaul Evolution

CISCO *Live!*



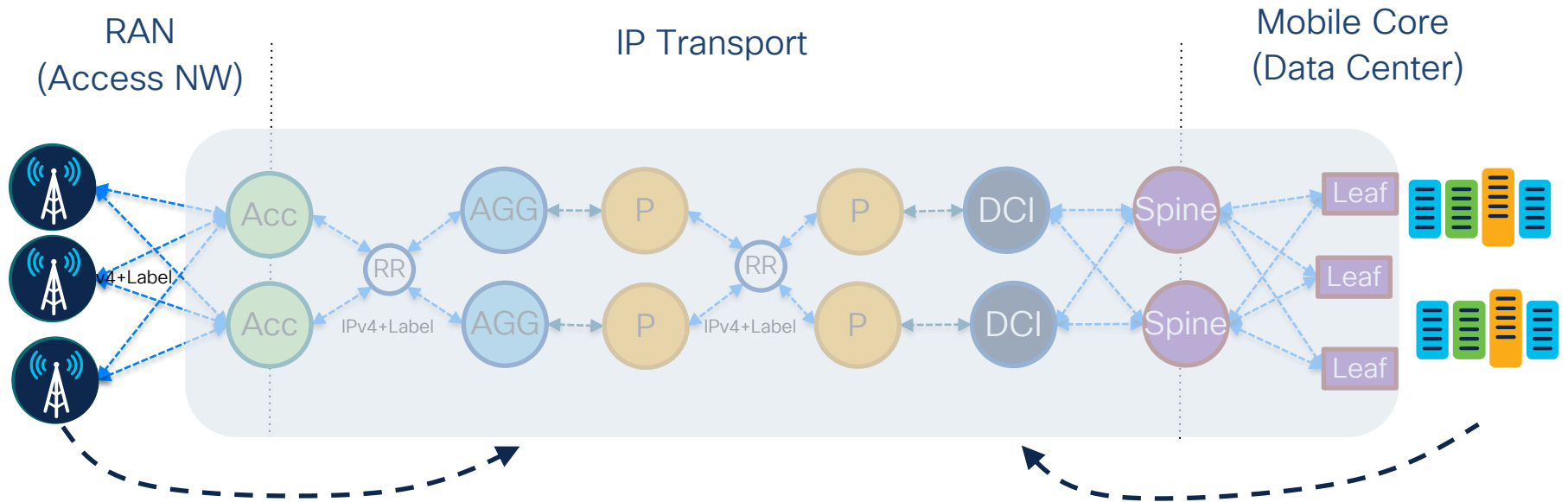
The Big Picture:

Mobile Transport getting intertwined with RAN and Packet Core



The Big Picture:

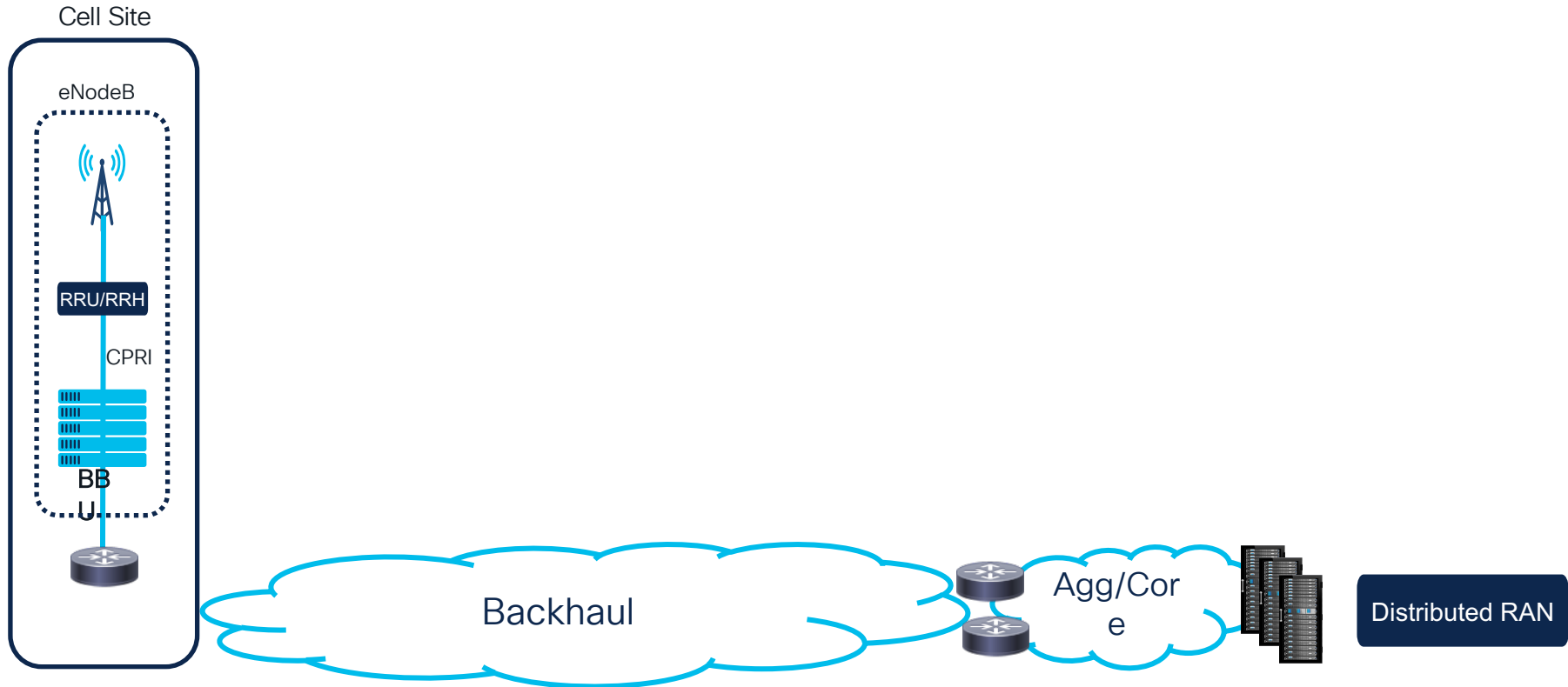
Mobile Transport getting intertwined with RAN and Packet Core



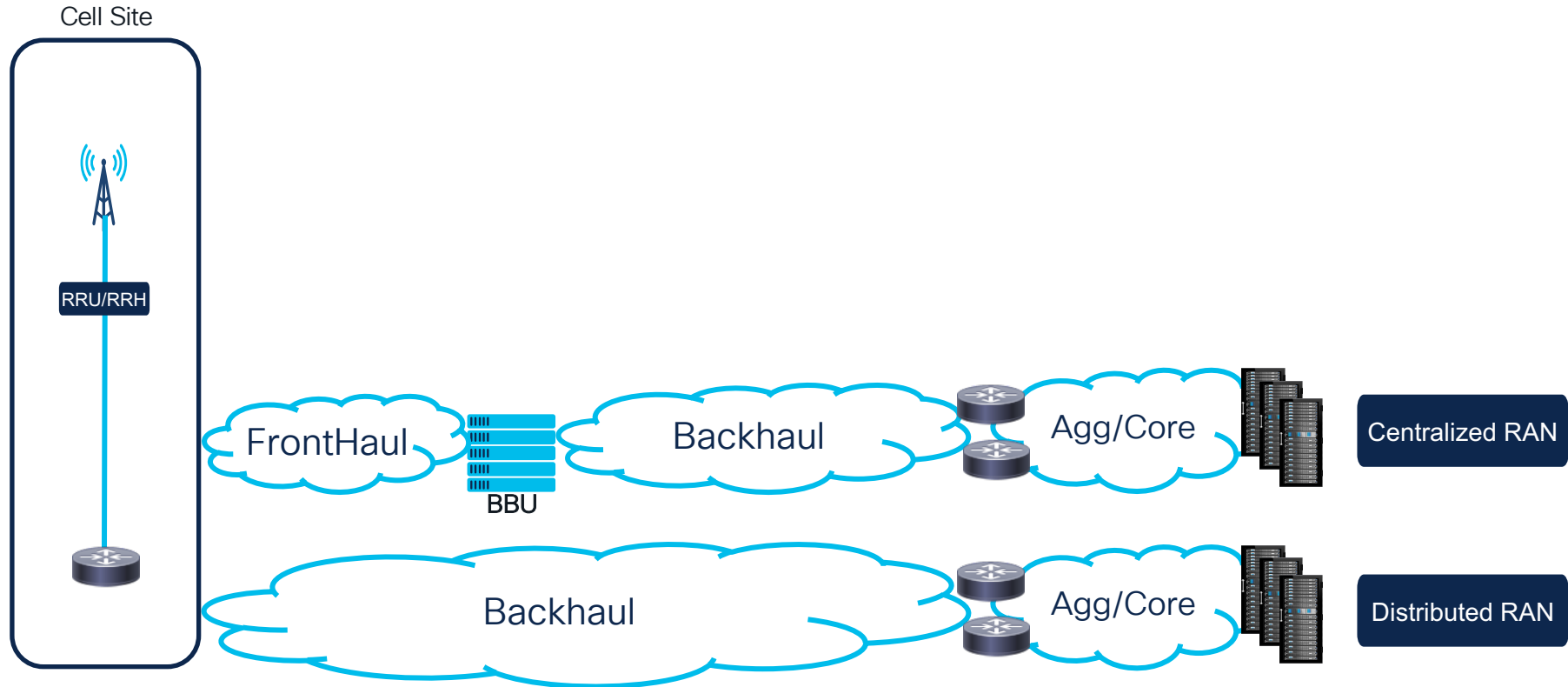
RAN Decomposition into Access/Aggregation Networks, resulting in centralized, cloud, virtual RAN Architectures

Packet Core decomposing and getting closer to user equipment for better traffic efficiency e.g. User Plane Function (UPF)

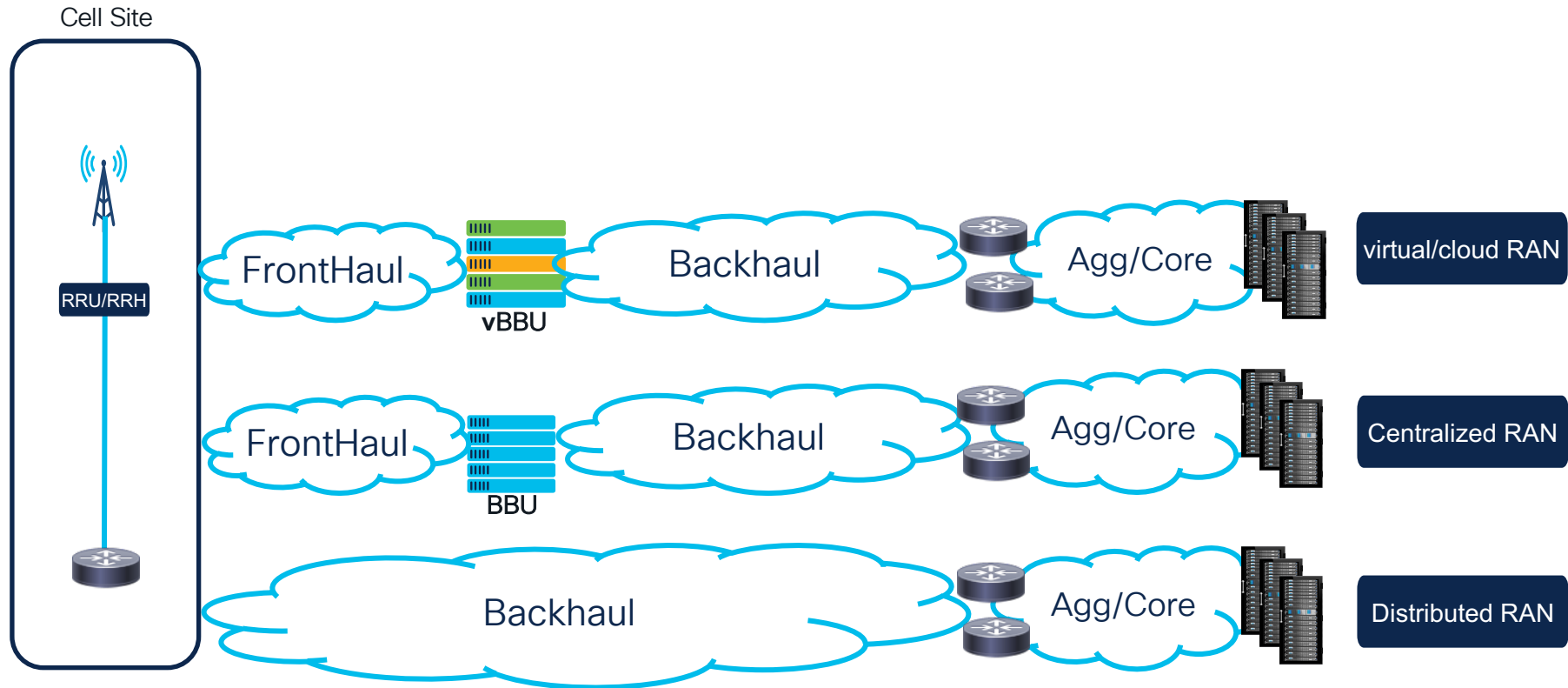
RAN Evolution Journey – From Backhaul to xHaul



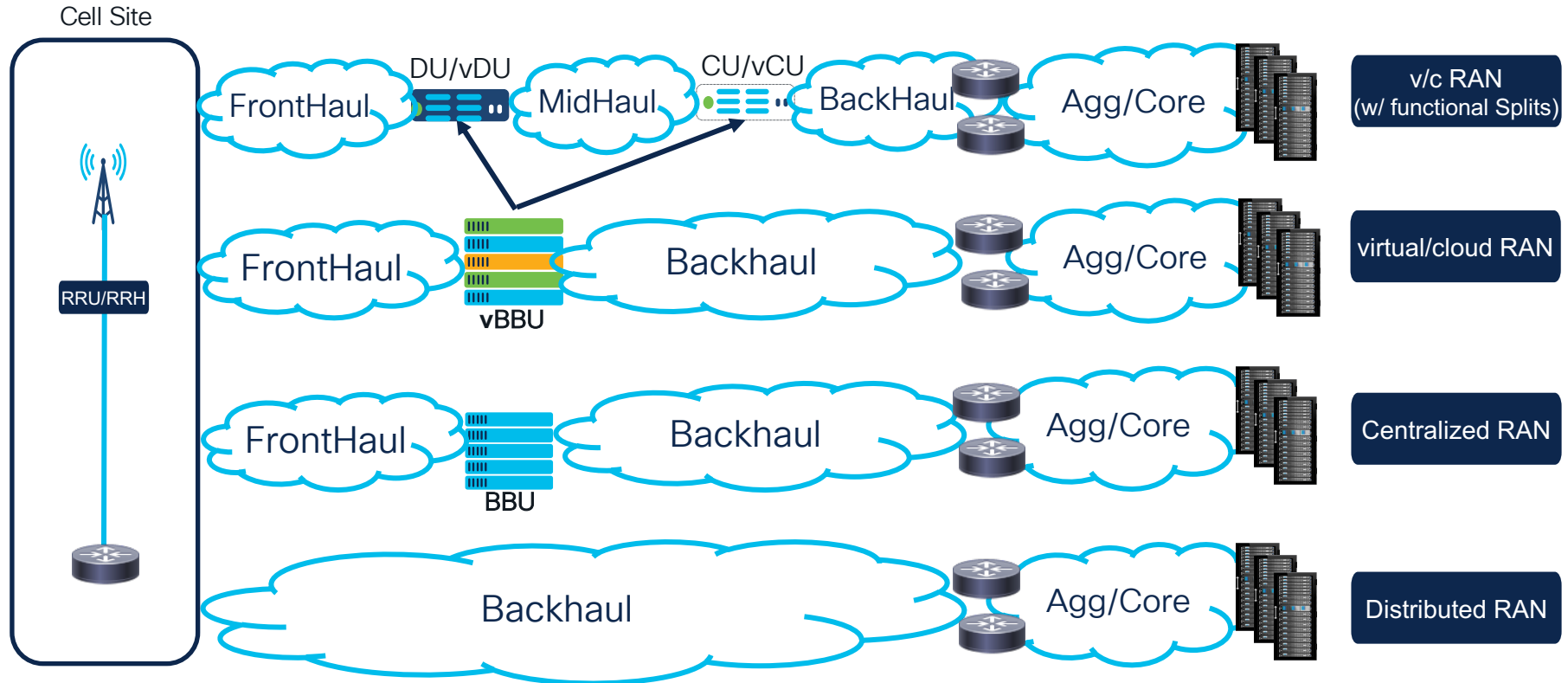
RAN Evolution Journey – From Backhaul to xHaul



RAN Evolution Journey – From Backhaul to xHaul



RAN Evolution Journey - From Backhaul to xHaul



Operator Defined xHaul Deployment Scenarios

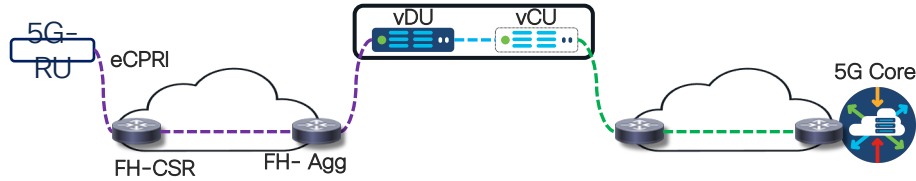
CISCO *Live!*



Operator Defined xHaul Deployment Scenarios

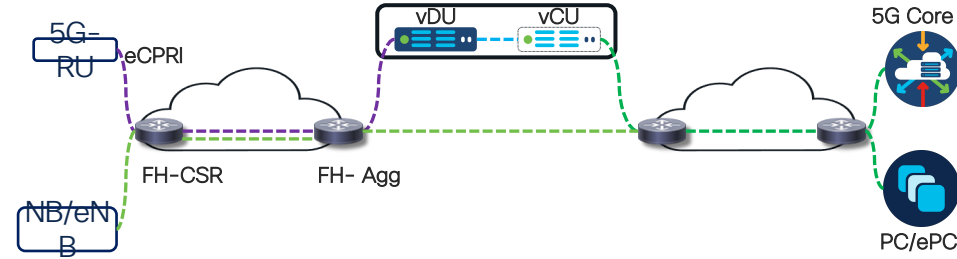
5G CRAN with Fronthaul and Collocated

DU/CU
C-RAN Hub



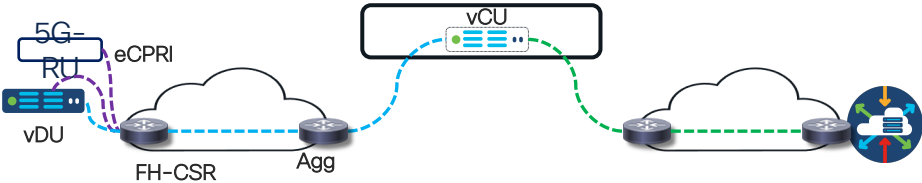
5G C-RAN Fronthaul with LTE Backhaul

Coexistence
C-RAN Hub



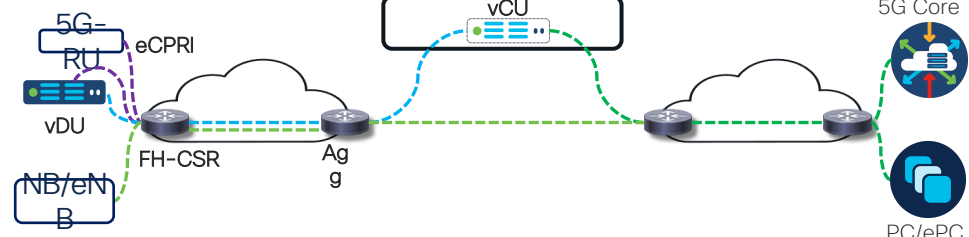
5G C-RAN with Midhaul and Collocated

RU/DU
C-RAN Hub



5G C-RAN Midhaul with LTE Backhaul

Coexistence
C-RAN Hub



Fronthaul Connection

Midhaul Connection

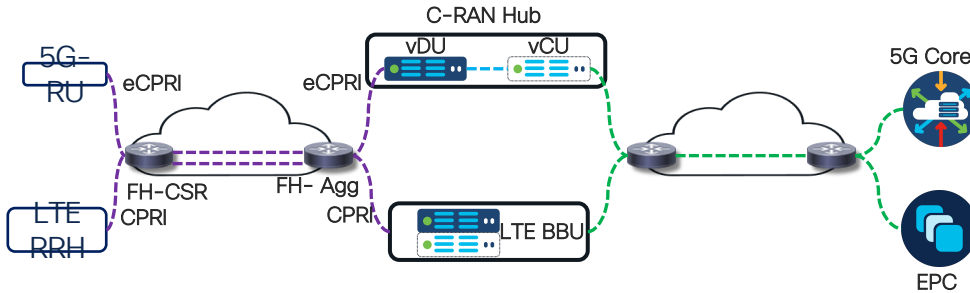
Backhaul Connection

CISCO Live!

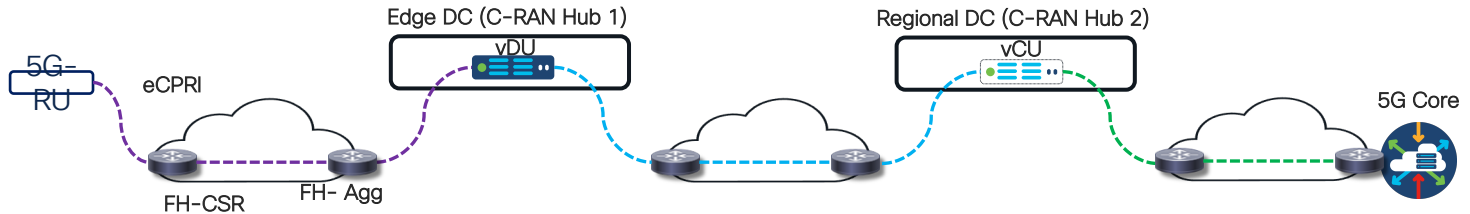
* As specified in O-RAN xHaul Packet Switched Network Architecture available at <https://www.o-ran.org/specification-access>

Operator Defined xHaul Deployment Scenarios*

5G CRAN Fronthaul and 4G Fronthaul Coexistence



Dual Split C-RAN Architecture



Fronthaul Connection

Midhaul Connection

Backhaul Connection

Design Considerations

CISCO *Live!*



xHaul Design Considerations



RAN Dimensioning

IP Bandwidth
Calculations



Domain Specific

xHaul Domains
Latency Limitations
Topology
Considerations



Technical

Transport underlay
& Services
Redundancy
Transport Scaling
Automation



Logistical

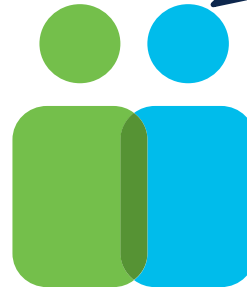
Cell site locations
BBU Hotel

RAN to IP Dimensioning Then



The RAN Gang

Hey IP Folks,
We are going to expand our footprint by
5k cell sites. Please make appropriate
preparations in IP Transport



The IP Team

Absolutely ... Lets use some RFC-
3107 compliant CSR to run BGP-LU or
BGP-SR for scale.

Lets talks about an end-to-end design
and get this going.

RAN to IP Dimensioning Now

Hey IP Folks,
As part of our 5G expansion, we are planning **5k MacroSites** with **3 sectors, 6 carriers** each. We have acquired some new sub-6GHz **Mid Bands** spectrum that we will use with **4T4R MIMO**. We'd use Open vRAN where possible with both **CPRI split 7 and 2**, but may have to use **split 8** only for legacy LTE sites. Please prepare your IP backhaul accordingly with Local and Regional DC to host compute for DU and CU.



The RAN Gang



The IP Team

Deciphering RAN Implications on Transport Design

RAN Clues	Transport Implications	Design Considerations
3 Sectors, 6 Carriers, Midbands, 4T4R MIMO	Calculate BW for all carriers and Bands Total BW per SITE for sectors/MIMO	Choose appropriate speed links and network BW capacity
O-RAN, where possible	Open Interfaces Possibly multivendor RU/DU/CU	Standardized Ethernet based CPRI transport May require interop test/integration of RAN
CPRI Split 7 and 2	xHaul transport with dual split Both Fronthaul and Midhaul domains Split 7's implication on Bandwidth	Plan for Edge and Regional DCs to host RAN Calculate appropriate bandwidth in each domain L2/L3 VPN services between RU/DU/CU/5G-Core
Split 8 only for Legacy LTE	Front haul and Backhaul only Traditional C-RAN Arch for LTE Proprietary CPRI interface b/w RU, BBU	Use CPRI capable FH routers Bookended FH CSR and FH Agg deployment Plan for appropriate CPRI bandwidth

Fronthaul/Midhaul/Backhaul Calculation

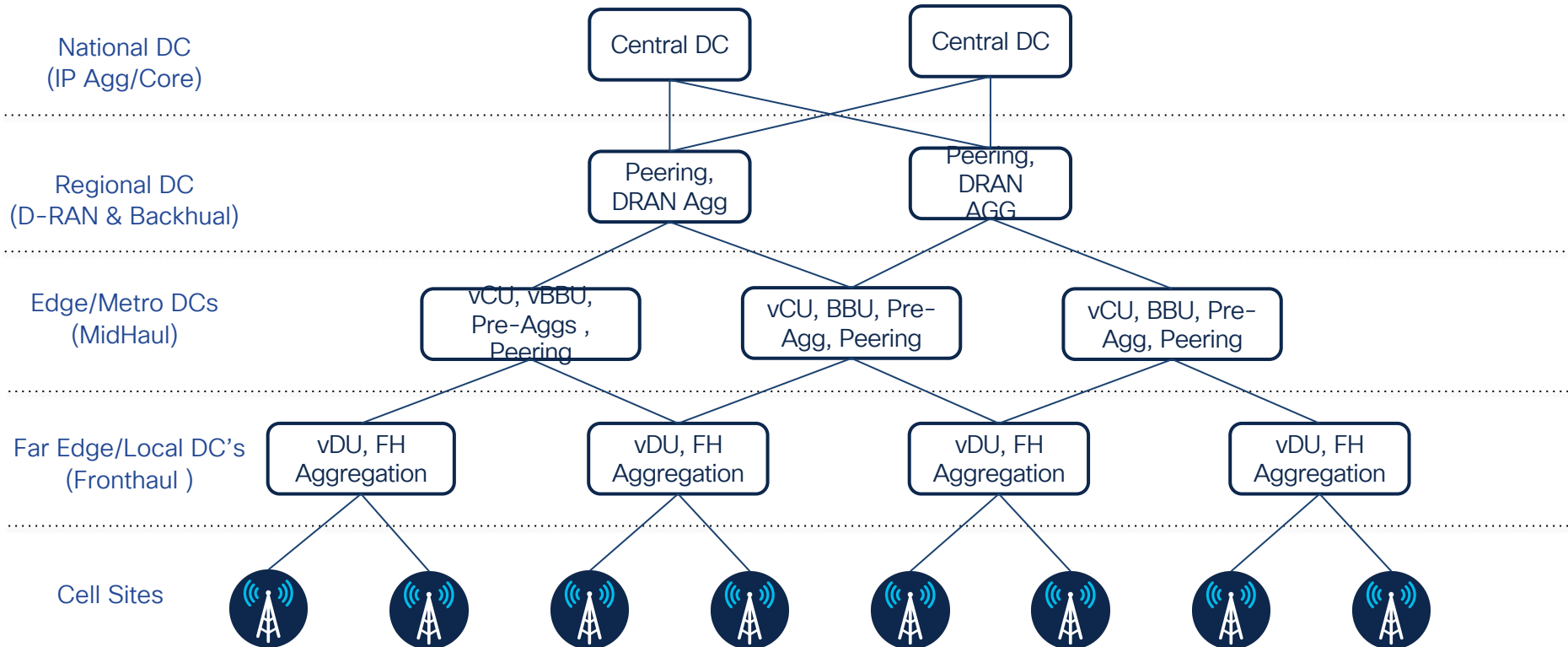
Single Cell Site/3 Sector 6 Carriers

PRB=Physical Resource Block
Statistical Multiplexing (Statmux)=1Max+2 Average

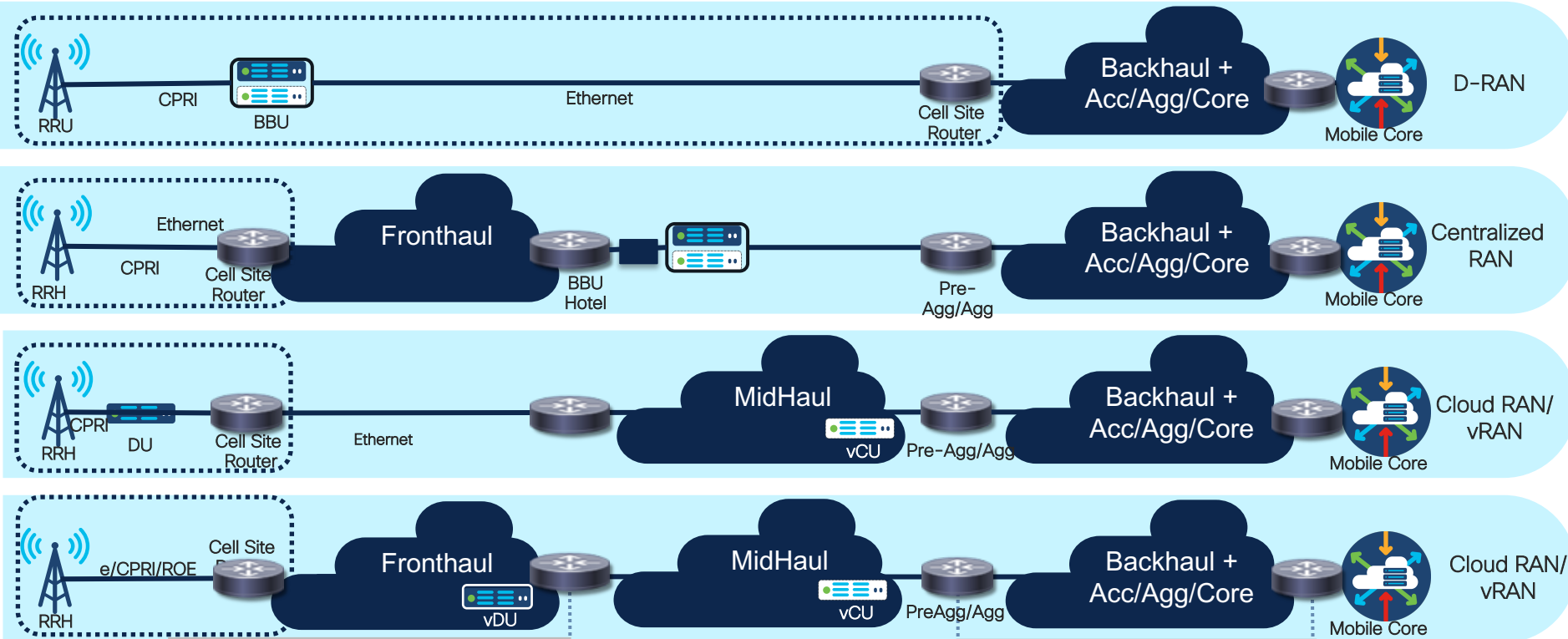
Band Number	Band	Bandwidth [MHz]	MIMO/MIMO Layers	Fronthaul Data Rate (Single Sector Peak) CPRI/ORAN Gbps	FH Data Rate ("3" Sectors) CPRI/ORAN Gbps	Midhaul Gbps	Backhaul Gbps
5	850 MHz	10	4T4R	2.45 (CPRI option 3)/0.70	7.35/1.40	0.23	0.20
8	900 MHz	10	4T4R	2.45 (CPRI option 3)/0.70	7.35/1.40	0.23	0.20
9	1.8GHz	20	4T4R	4.9 (CPRI option 5)/1.40	14.7/2.80	0.47	0.40
41	2.6GHz	20	4T4R	9.8 (CPRI option 7)/1.40	29.4/2.80	0.47	0.40
n78	3.5GHz	100	64T64R/8 layers	15.29	30.59	4.44	3.78
n257	28GHz	400	128T128R/4 layers			6.5	5.3
Total					89.39/39 Gbps	12.34 Gbps	10.28 Gbps

Fronthaul Interface Required=100G/50
Midhaul Interface Required=25G
Backhaul Interface Required=25G

xHaul Transport and Data Center Integration

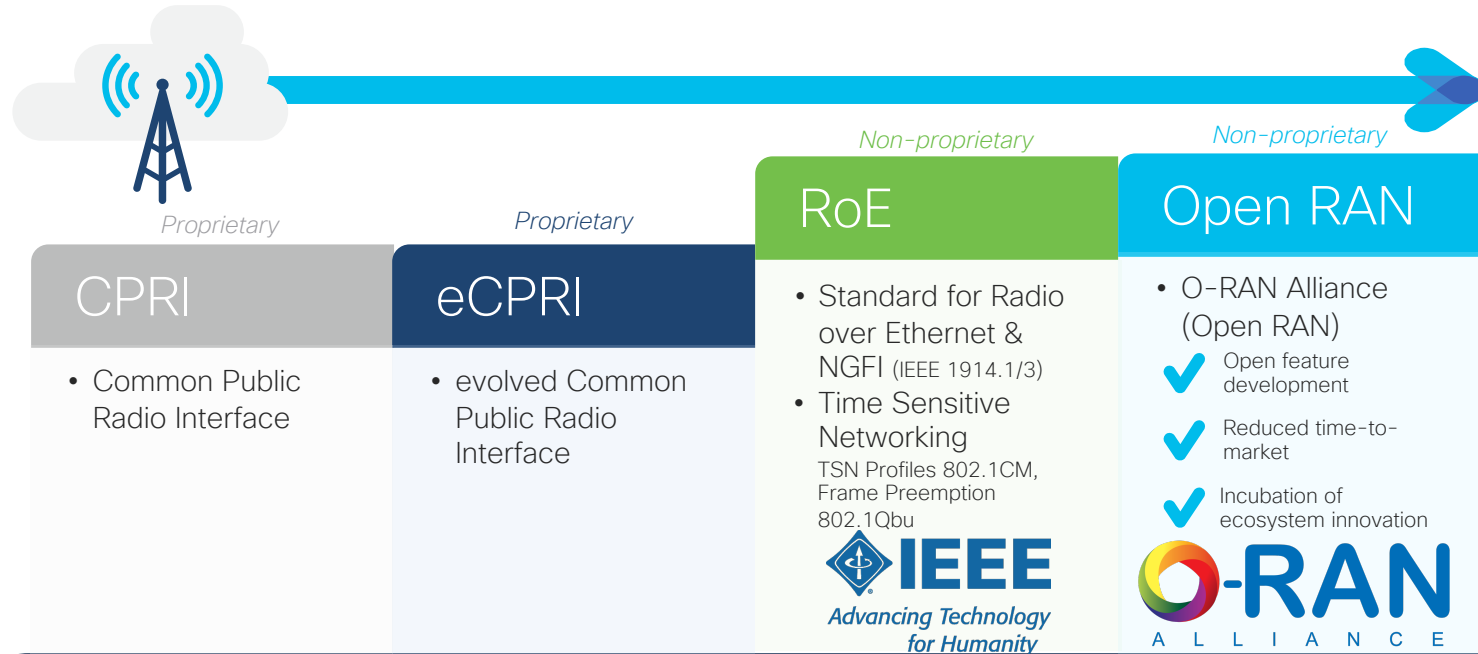


Latency and Distance Considerations across xHaul Domains



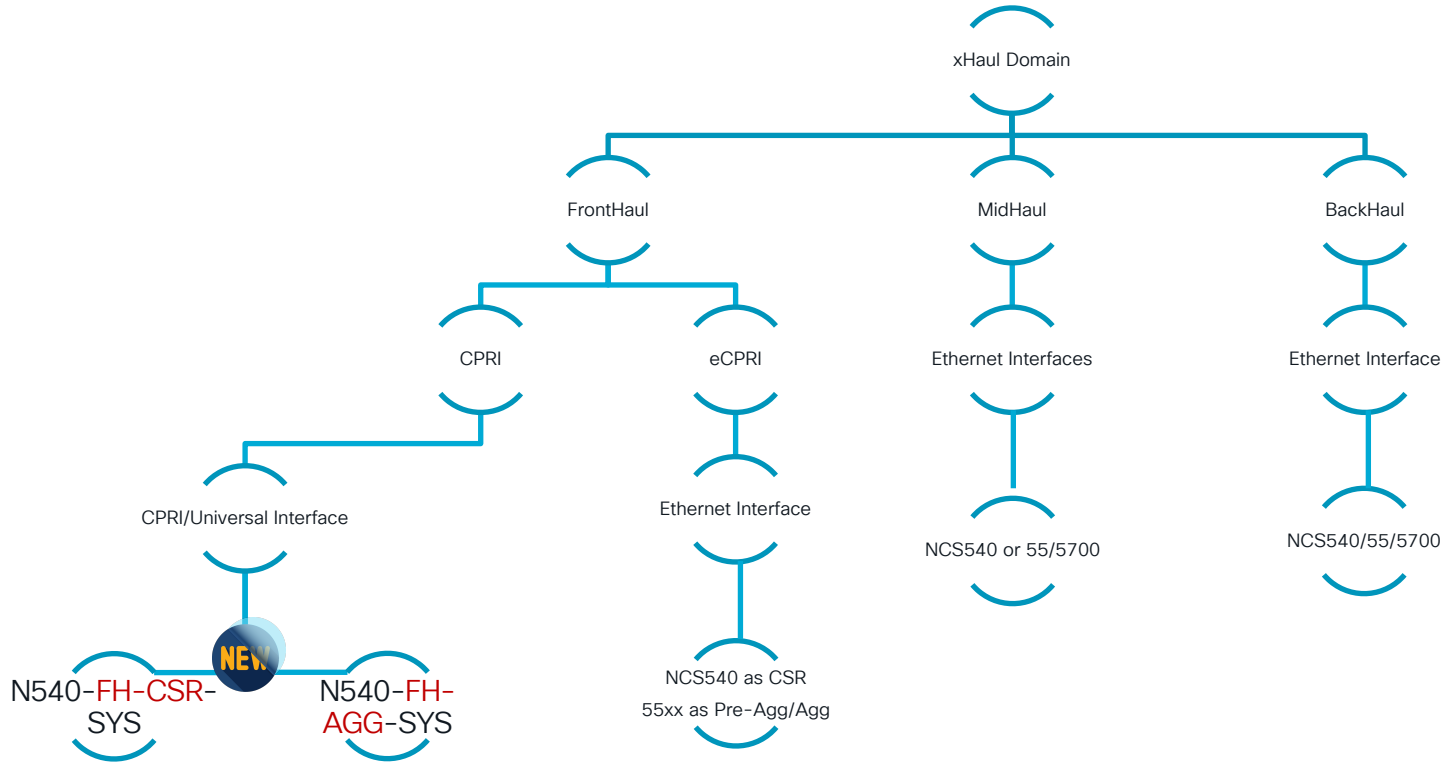
	Fronthaul	Midhaul	Backhaul
1-way Latency	75/100 uSec (LTE) 150 us (5G NR uRLLC)	1 - 25 msec	1-way Latency 10msec
Typical Distance	<15km	>10km	Typical Distance >10km
Interfaces	Ethernet/CPRI/eCPRI	10/25/100G Ethernet	Interfaces 10/25/100/400G

CPRI Interface Evolving towards Open RAN



Driving towards open standards for RAN Interfaces

xHaul Device Selection - CSR Interface



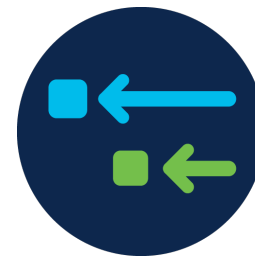
Other xHaul Technical Considerations



New FrontHaul
Interfaces



Programmable
Underlay



EVPN Overlay



Edge DC's for
vRAN



Timing &
Synchronization



Transport SDN
& Automation

Summary



RAN Evolution Summary



Distributed RAN – Each Cell site has Antenna's, Radio Unit or Remote Radio Head and Baseband Unit (BBU)



Centralized RAN – BBU is centralized, still closed system, limited real-estate benefits, uses CPRI Fronthaul



Cloud/Virtual RAN – BBU is virtualized, a step towards COTS hardware



vRAN (Functional Splits) – BBU split into DU and CU. Requires Front Haul, MidHaul and Backhaul ... xHaul



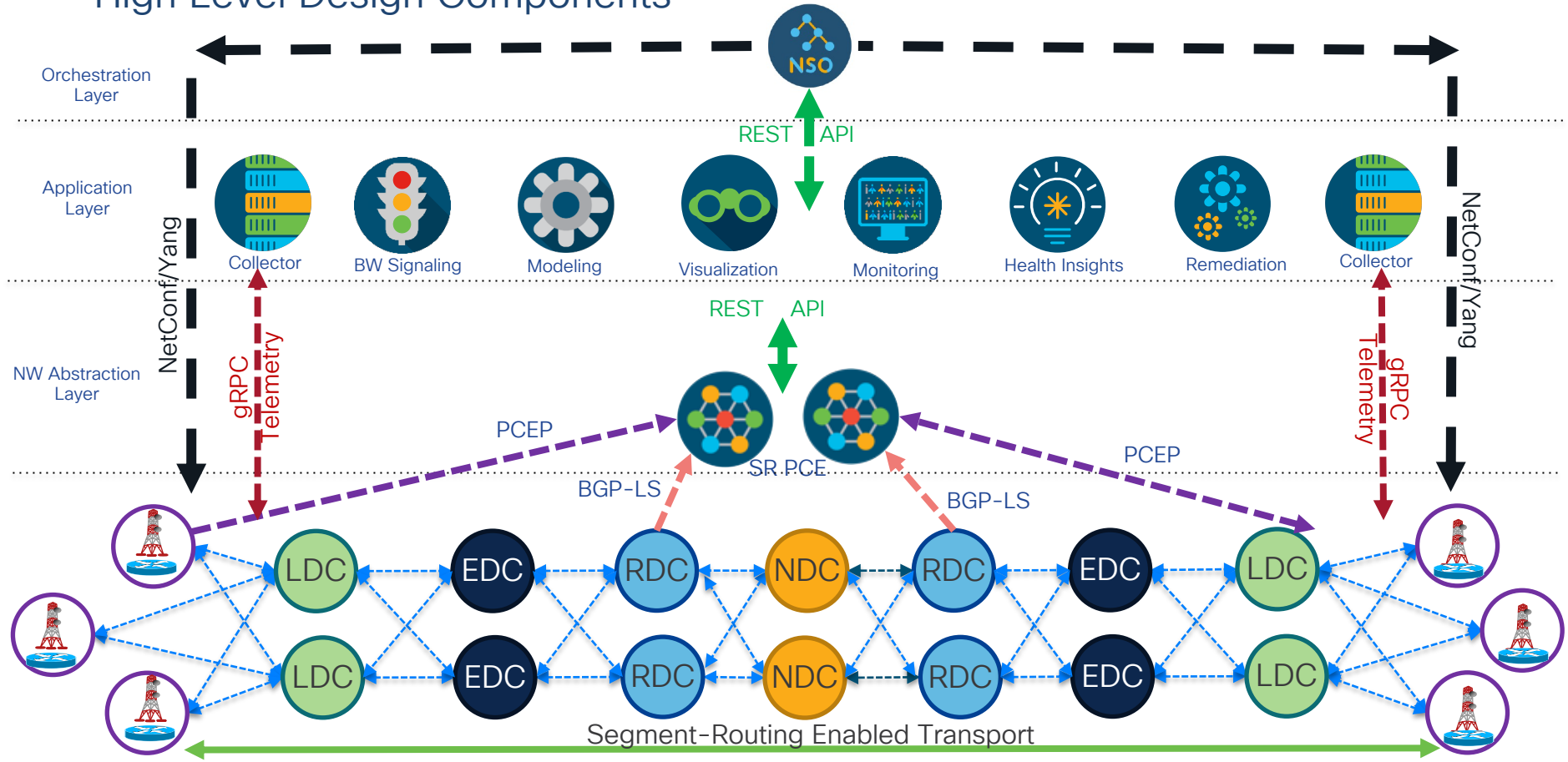
Open vRAN/ORAN/OvRAN – O-RAN alliance for open interfaces, usecases, arch etc

Design Summary

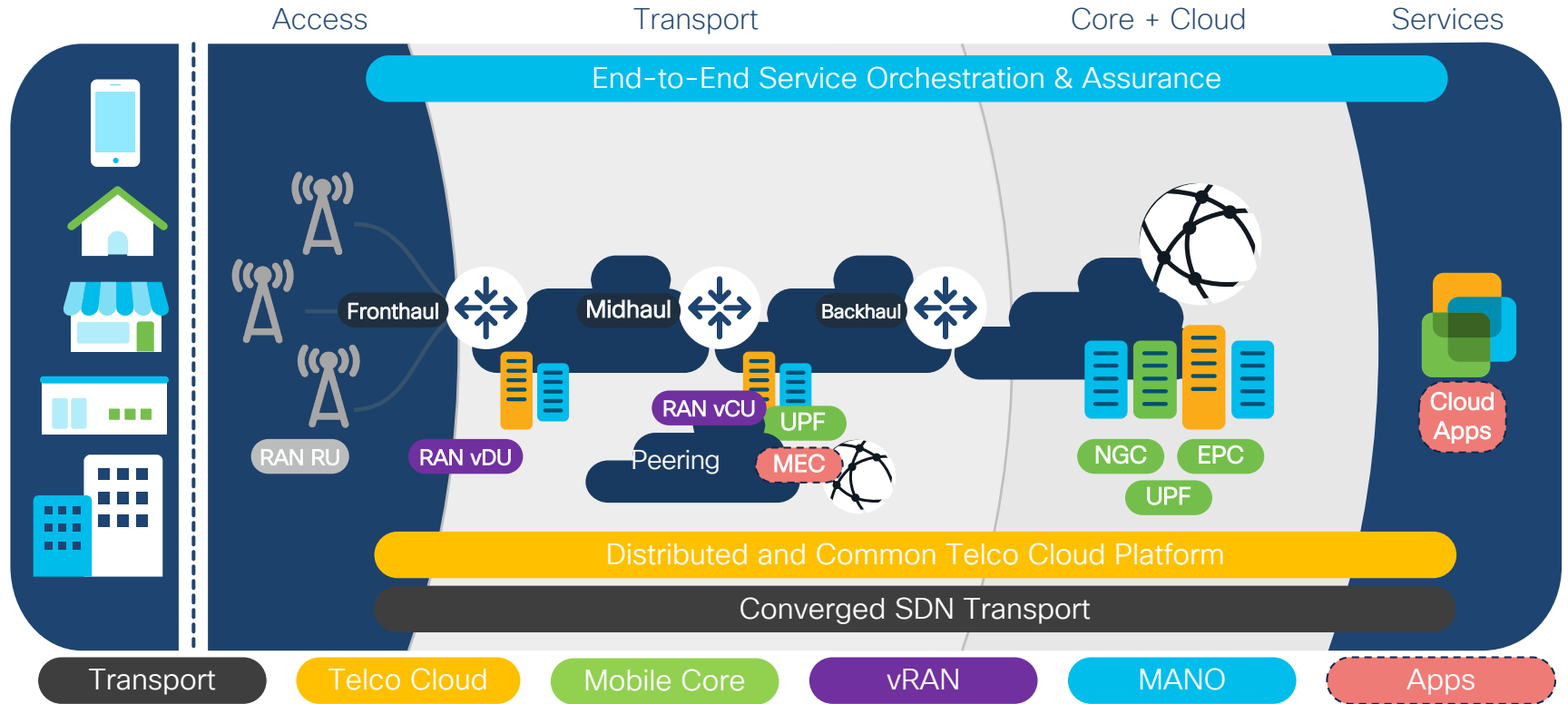
- Packetized FrontHaul Latency Consideration
 - Bookended Solution – 25usec latency between 2xNCS540's
 - 75/100 usec budget for transport
 - 15km max ($5\mu\text{s} \times 15\text{km} = 75\text{usec}$) if using P2P link
 - **Consideration for additional devices if ring topology is used**
- Bandwidth consideration
 - D-RAN: 4G/LTE, for the most part had sub 1G speed from BBU to CSR
 - CPRI is highly dependent upon split options 3, 5, 7, 8
 - Split functionality (e.g. option 3 has more processing at DU hence lower BW than split 8)

Software Defined Mobile Transport Networks

High Level Design Components



5G Network Transport Evolution



Supporting Sessions

BRKSPM-2001	5G Converged SDN Transport
BRKSPM-2000	5G Access and DC Edge
BRKSPG-2065	Packet Based Front Haul
BRKSPG-2060	5G Transport: Design Strategies



The bridge to possible

Thank you

CISCO Live!

#CiscoLive





TURN
IT
UP

CISCO *Live!*

#CiscoLive