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The bridge to possible

5G xHaul Transport

Design Considerations, Strategies and Best Practices

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BRKSPG-2060

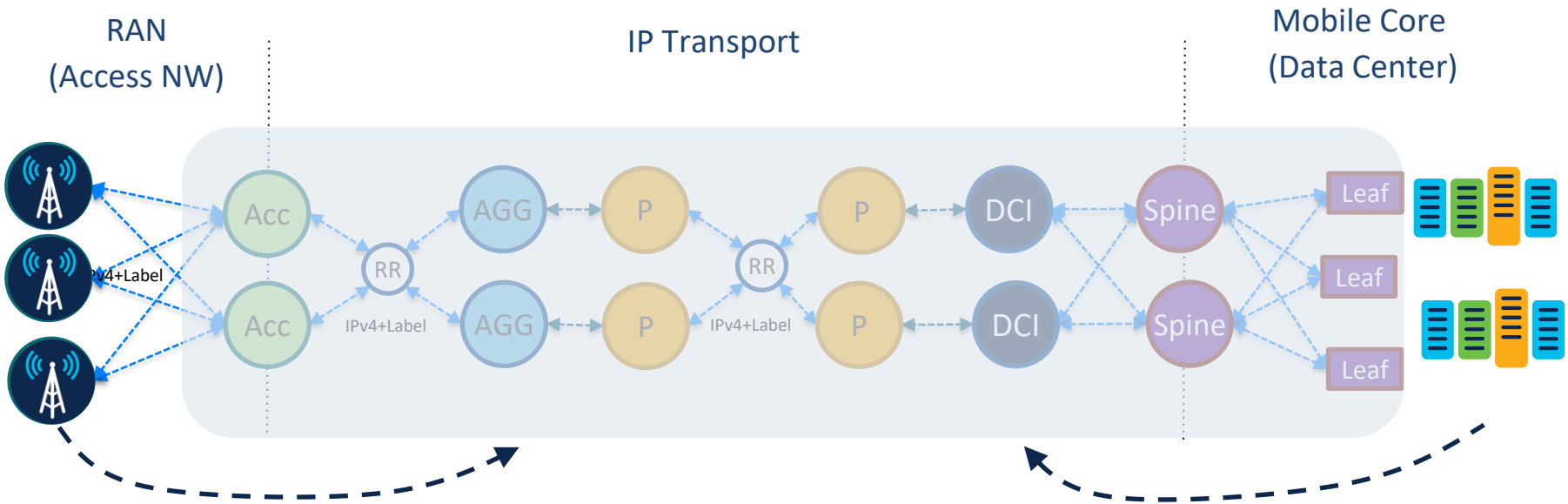
Agenda

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

RAN/xHaul Evolution

The Big Picture:

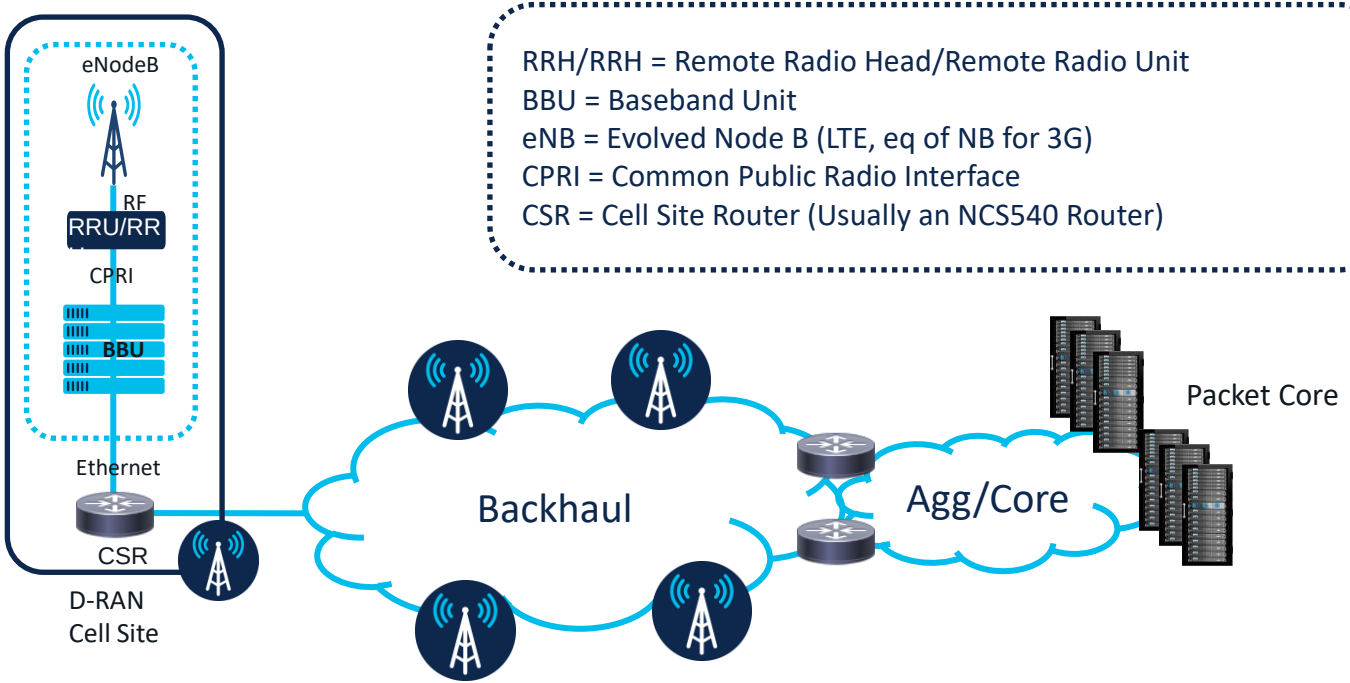
Mobile Transport getting intertwined with RAN and Packet Core



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

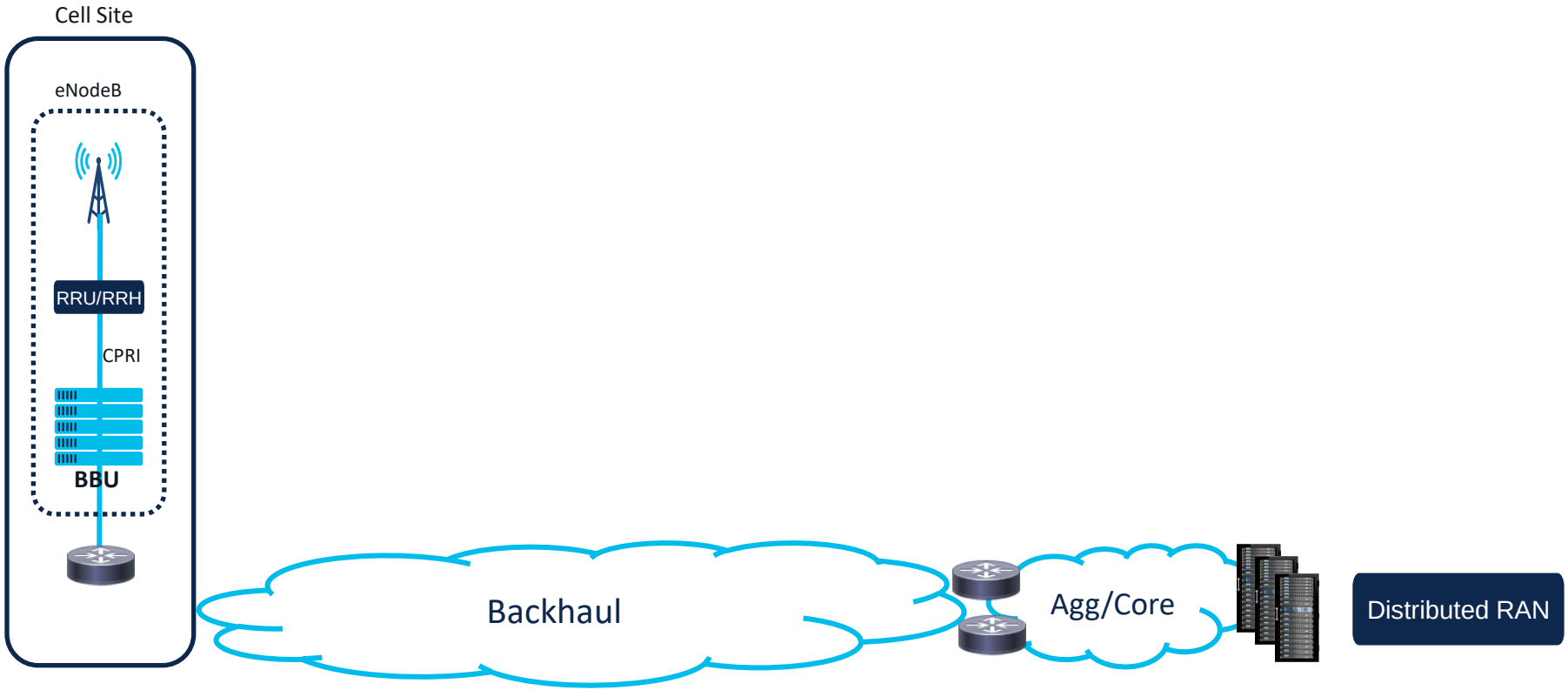
Packet Core decomposing and getting closer to user equipment for better traffic efficiency e.g. User Plane Function (UPF)

Understanding D-RAN Terminologies



RRH/RRH = Remote Radio Head/Remote Radio Unit
BBU = Baseband Unit
eNB = Evolved Node B (LTE, eq of NB for 3G)
CPRI = Common Public Radio Interface
CSR = Cell Site Router (Usually an NCS540 Router)

RAN Evolution Journey – From Backhaul to xHaul



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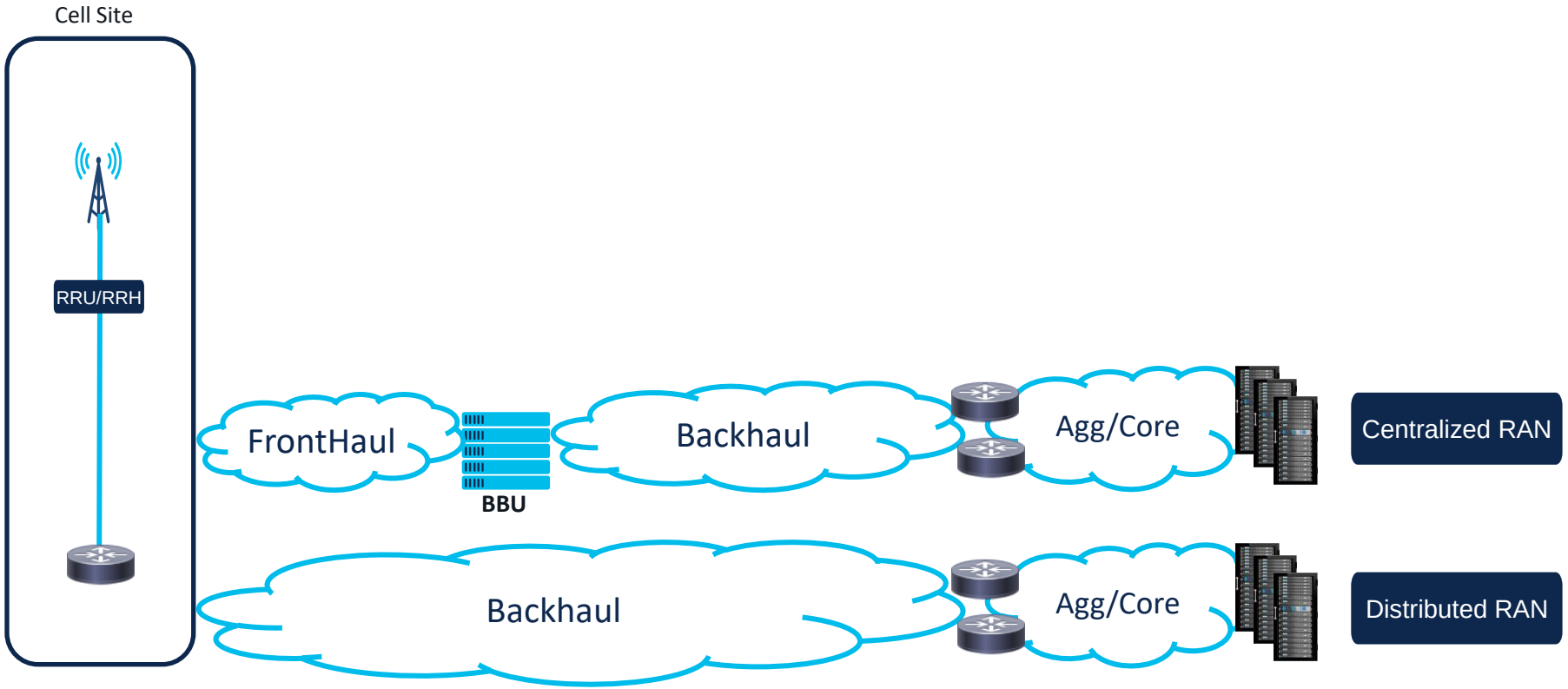

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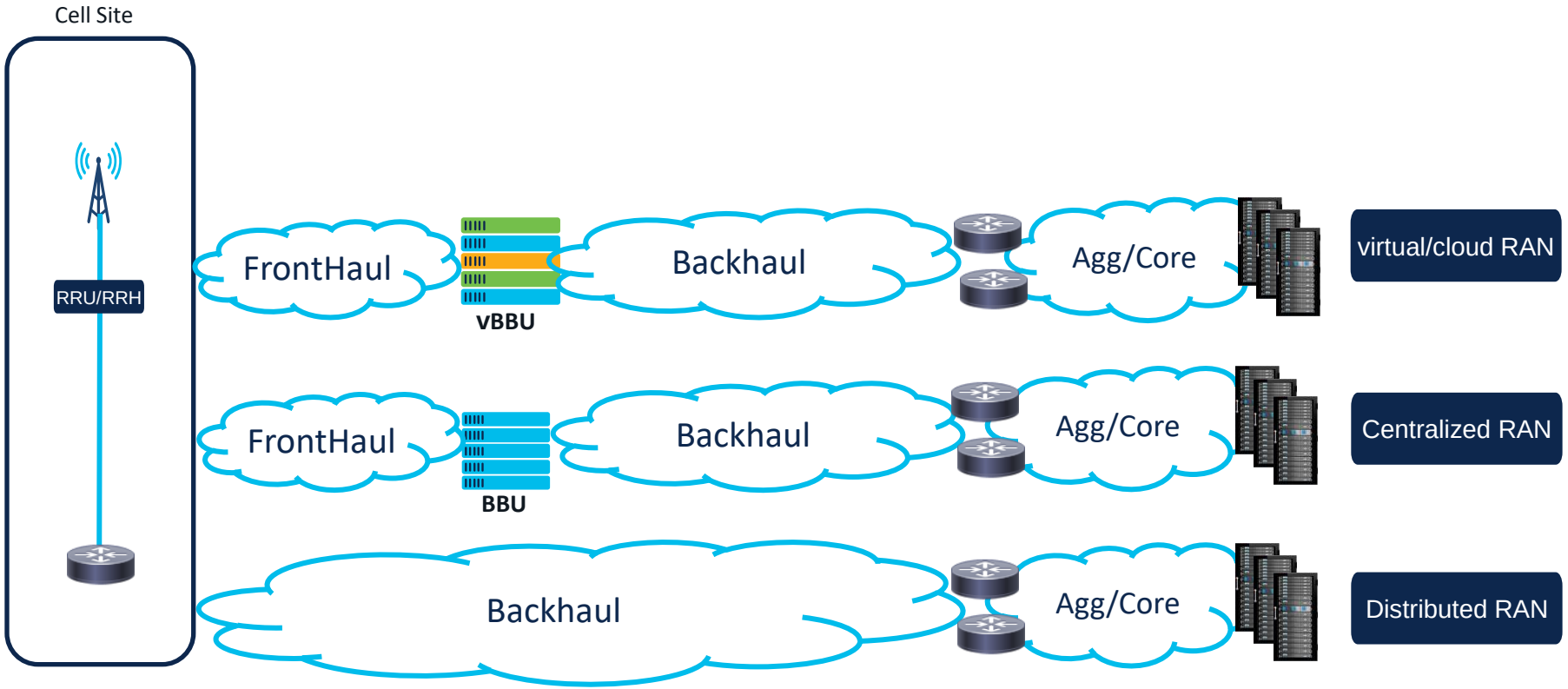

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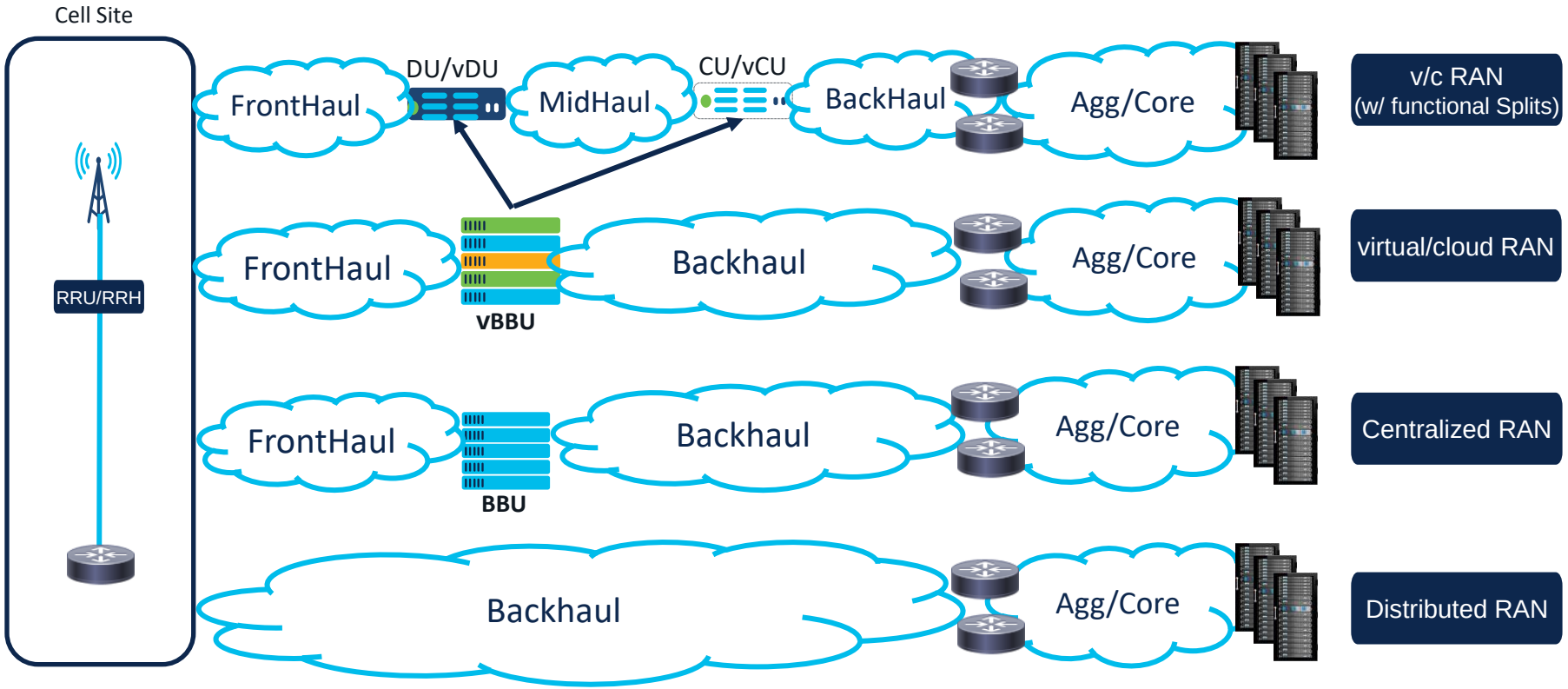
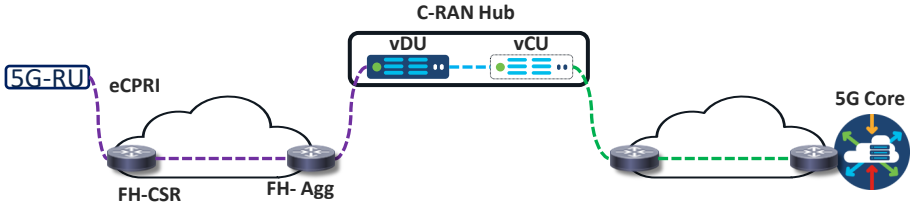


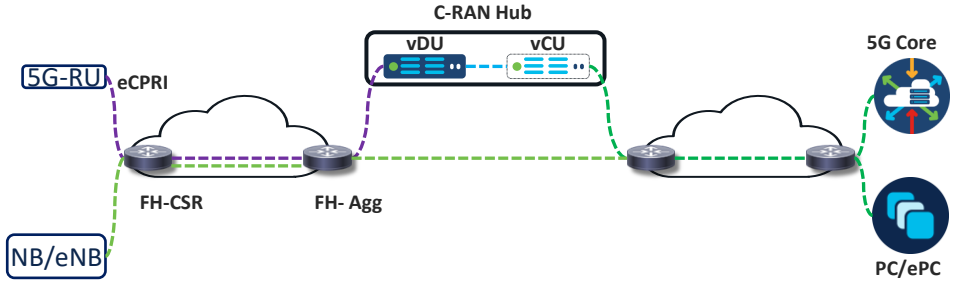
Operator Defined xHaul Deployment Scenarios

Operator Defined xHaul Deployment Scenarios*

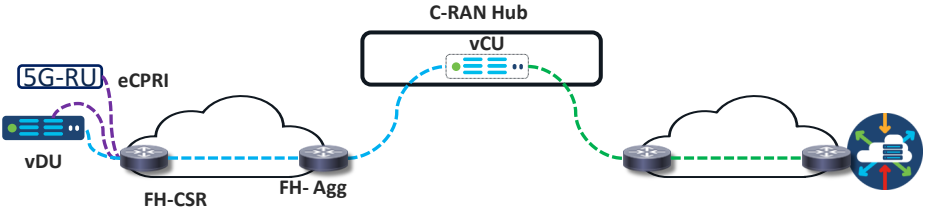
5G CRAN with Fronthaul and Collocated DU/CU



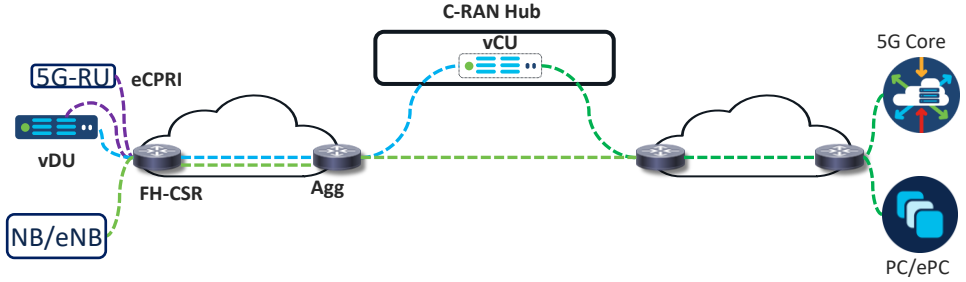
5G C-RAN Fronthaul with LTE Backhaul Coexistence



5G C-RAN with Midhaul and Collocated RU/DU



5G C-RAN Midhaul with LTE Backhaul Coexistence



Fronthaul Connection

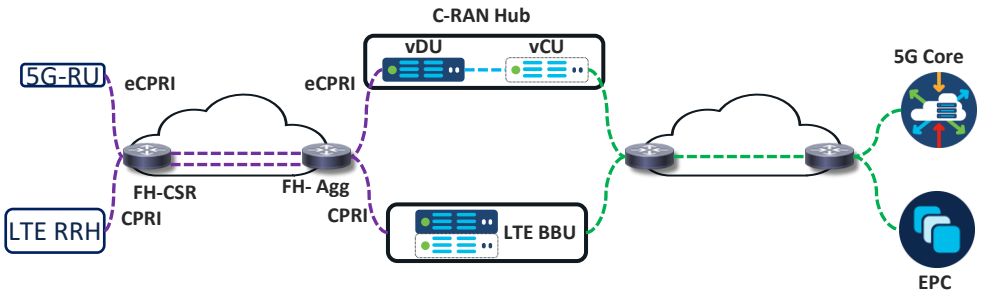
Midhaul Connection

Backhaul Connection

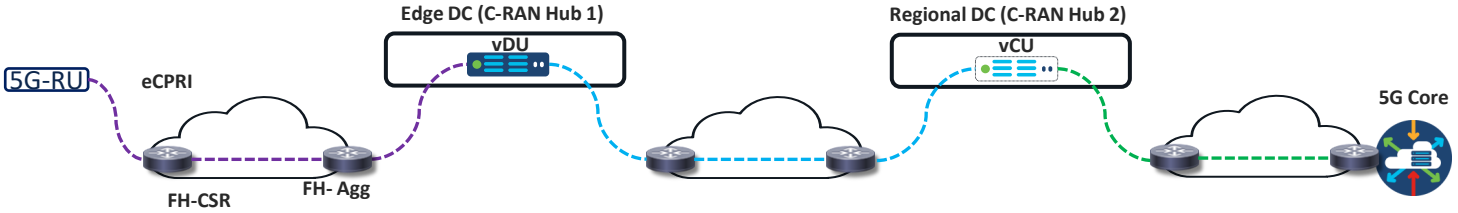
* As specified in O-RAN xHaul Packet Switched Network Architecture available at https://www.o-ran.org/specification-access

Operator Defined xHaul Deployment Scenarios*

5G CRAN Fronthaul and 4G Fronthaul Coexistence



Dual Split C-RAN Architecture



Fronthaul Connection

Midhaul Connection

Backhaul Connection

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Design Considerations

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

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 acquires 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

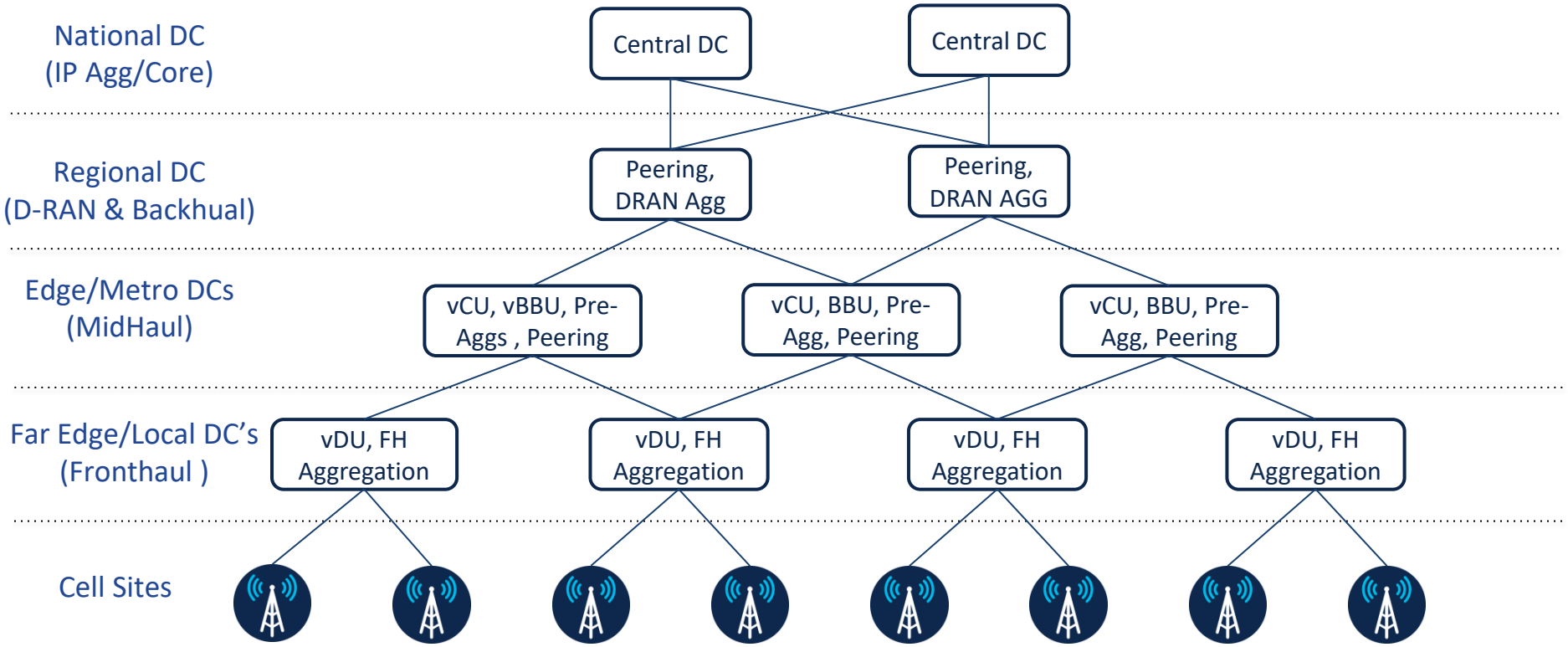
Single Cell Site/3 Sector 6 Carriers

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

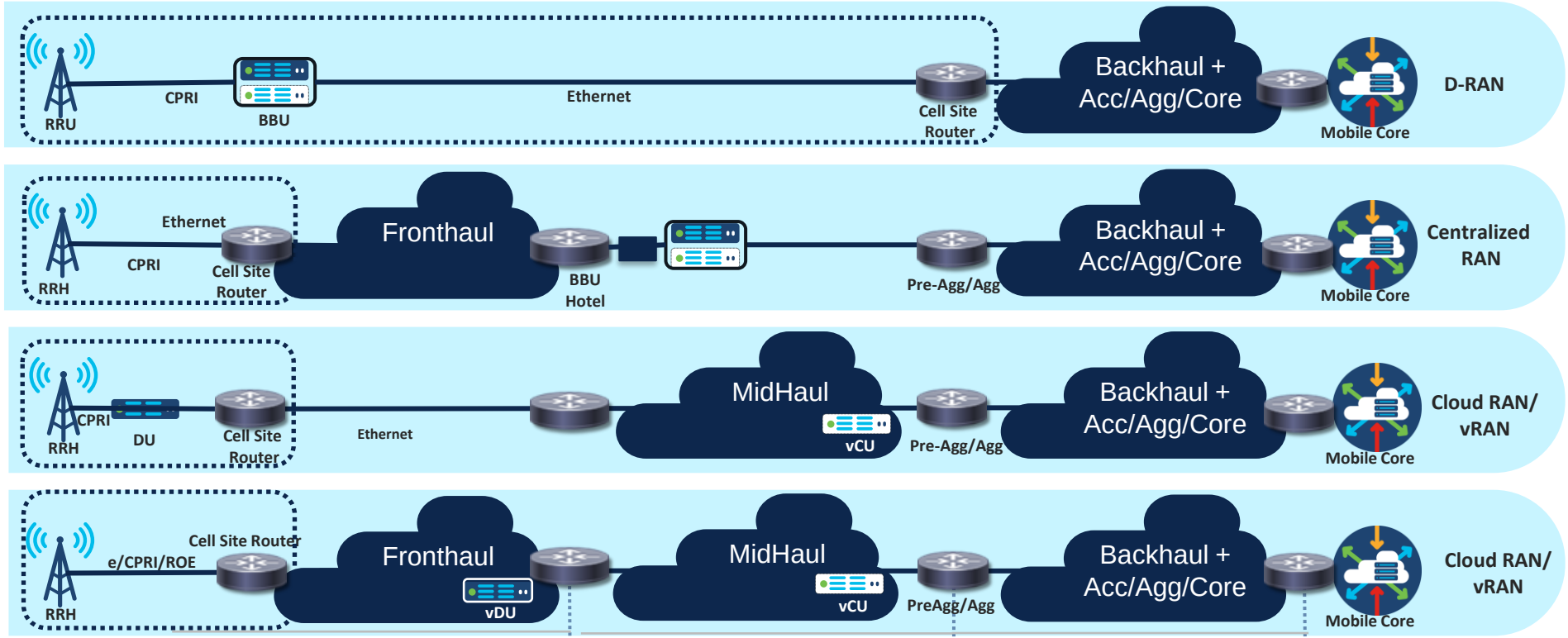
Band Number	Band	Bandwidth [MHz]	MIMO/MIMO Layers	Fronthaul Data Rate (Single Sector Peak) CPRI/ORAN Gbps	FH Data Rate ("3" Sectors) CPRI/ORAN Gbps	Midhaul Gbps	Backhaul Gbps
5	850 MHz	10	4T4R	2.45 (CPRI option 3)/0.70	7.35/1.40	0.23	0.20
8	900 MHz	10	4T4R	2.45 (CPRI option 3)/0.70	7.35/1.40	0.23	0.20
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/50G
Midhaul Interface Required=25G
Backhaul Interface Required=25G

xHaul Transport and Data Center Integration



Latency and Distance Considerations across xHaul Domains

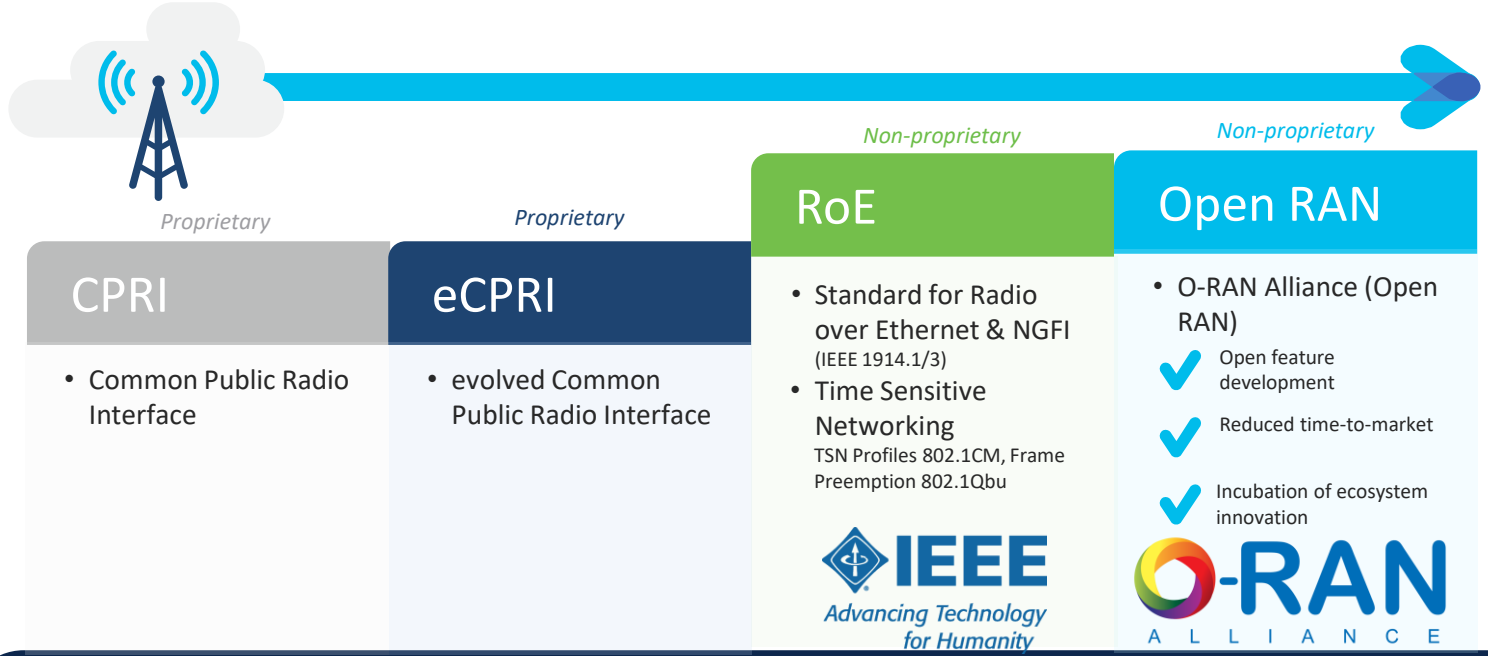


	Fronthaul
1-way Latency	75/100 uSec (LTE) 150 us (5G NR uRLLC)
Typical Distance	<15km
Interfaces	Ethernet/CPRI/eCPRI

	Midhaul
1-way Latency	1 – 25 msec
Typical Distance	>10km
Interfaces	10/25/100G Ethernet

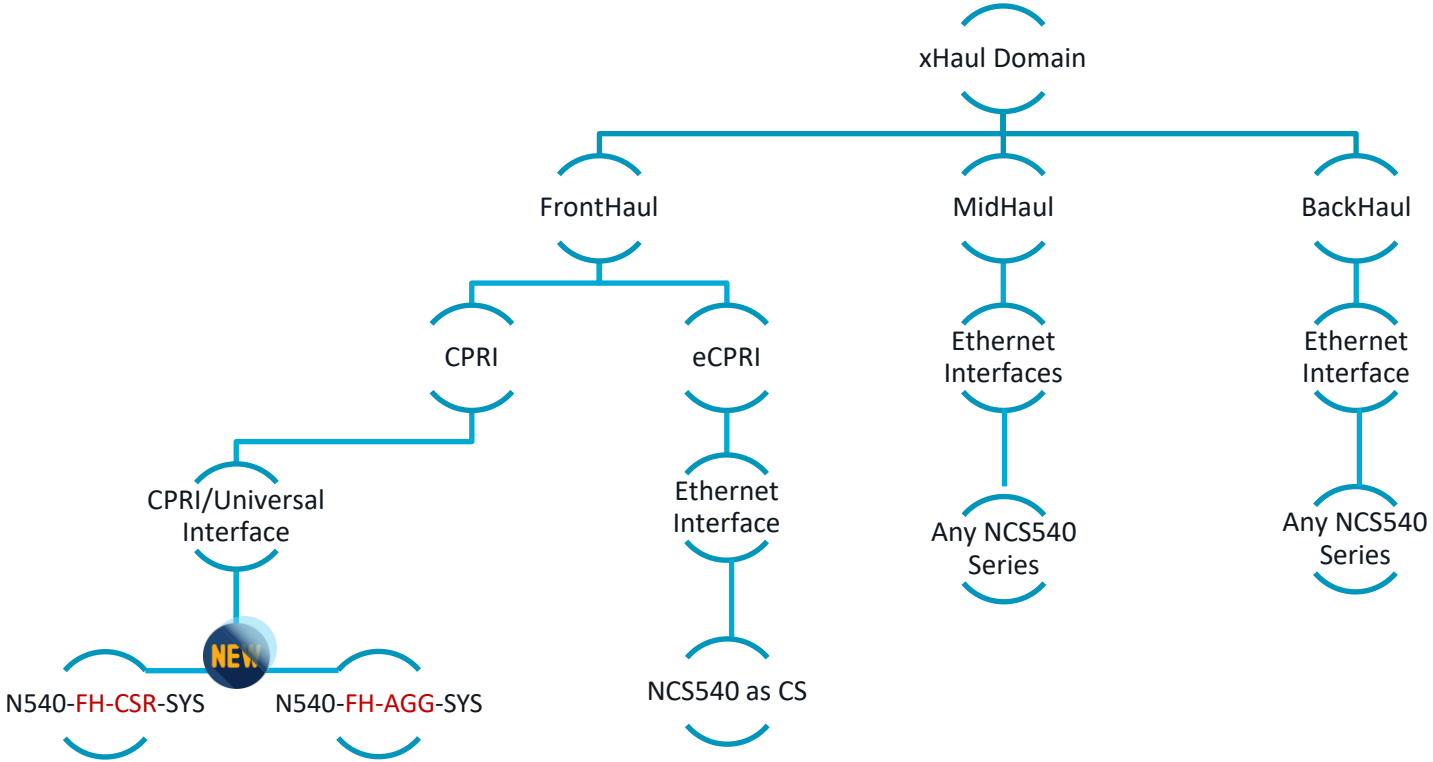
	Backhaul
1-way Latency	10msec
Typical Distance	>10km
Interfaces	10/25/100/400G

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

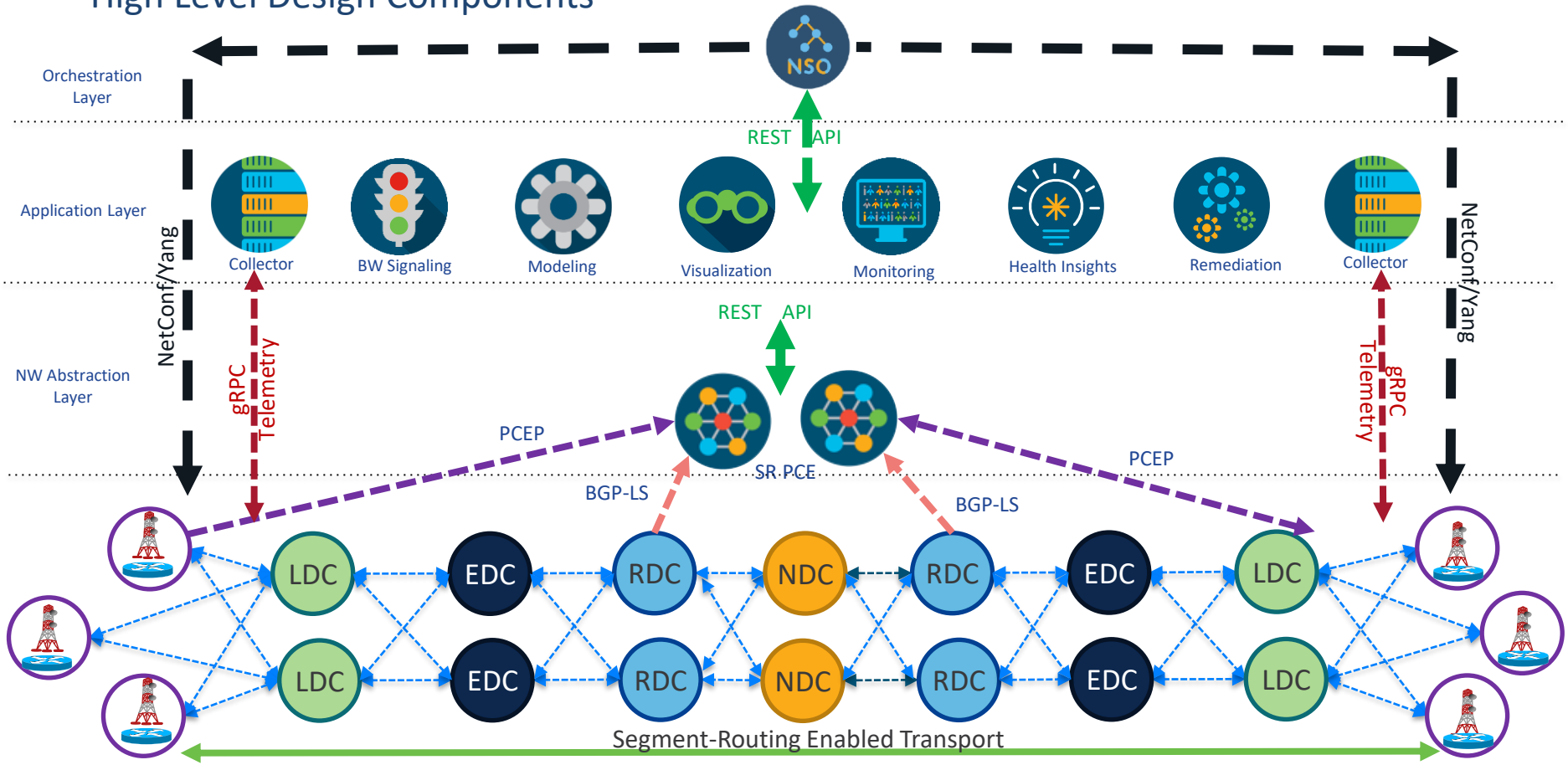
Open vRAN/ORAN/OvRAN – O-RAN alliance for open interfaces, usecases, arch etc

Design Considerations Summary

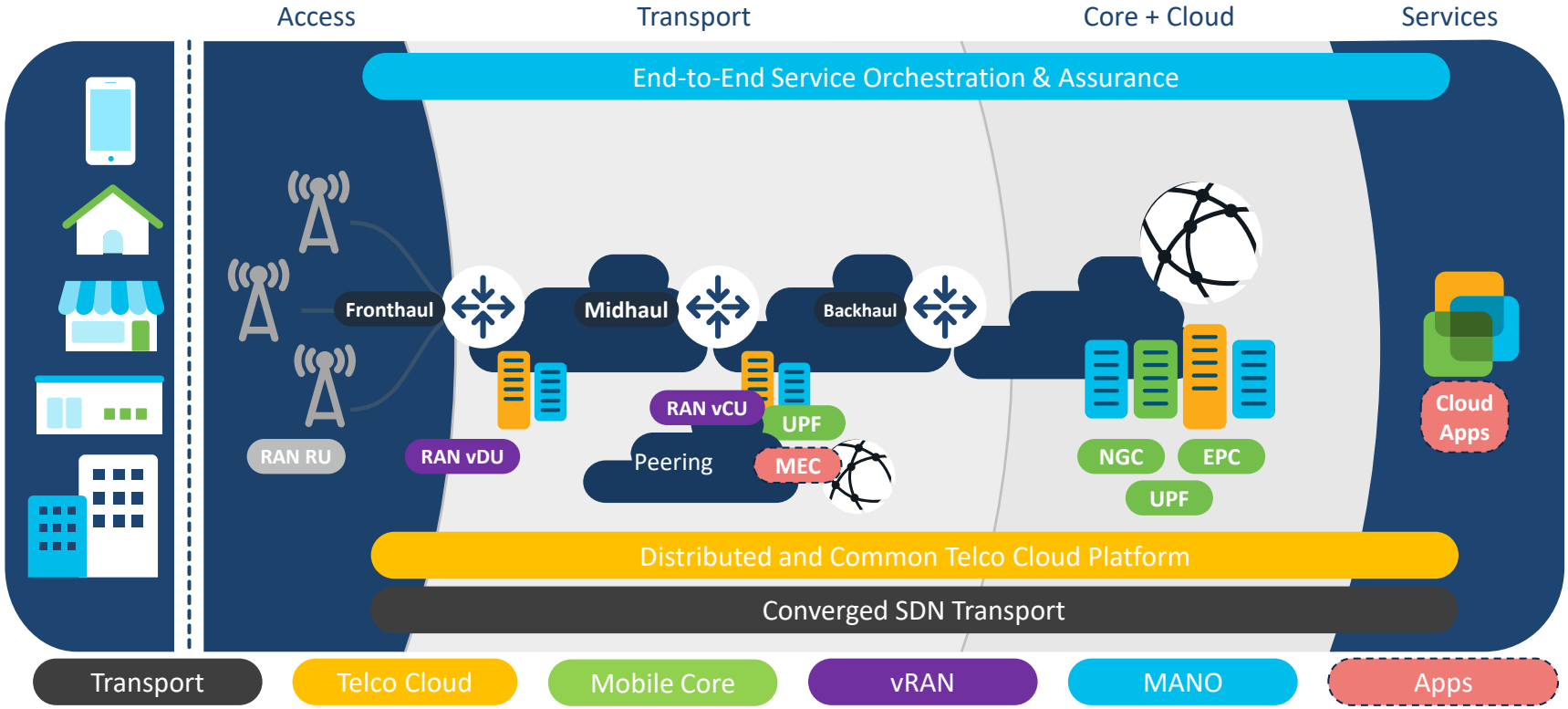
- Packetized FrontHaul Latency Consideration
  - Bookended Solution – 25usec latency between 2xNCS540's
  - 75/100 usec budget for transport
  - 15km max (5us x 15km = 75usec) if using P2P link
  - Consideration for additional devices if ring topology is used
- Bandwidth consideration
  - D-RAN: 4G/LTE, 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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