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The bridge to possible

5G RAN Transport Architecture

Shahid Ajmeri, Sr. Product Manager

BRKSPM-2977

Cisco Webex App

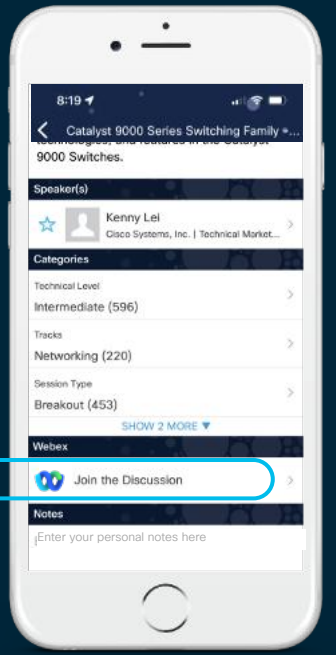
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Agenda

- 5G RAN Architecture
- Brownfield RAN Solution
- Cisco Converged SDN Transport
- Cloud-Ready Converged SDN Transport
- Key Takeaways

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5G RAN Architecture



5G RAN Transformation

Architectural Shifts Impacting the Evolution of RAN Transport



Radio Technology Innovation



Higher frequency spectrum



Larger radio channels

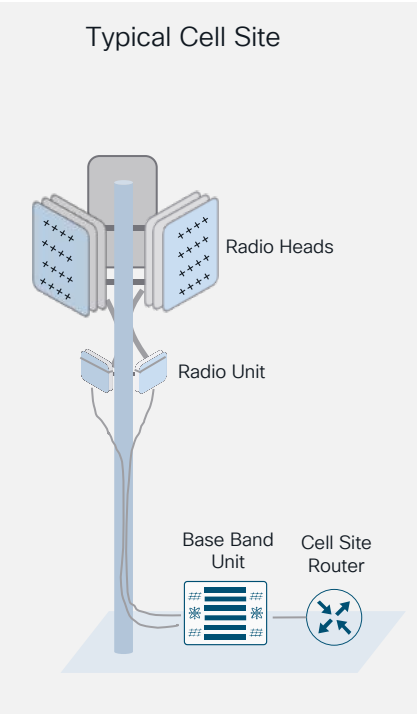


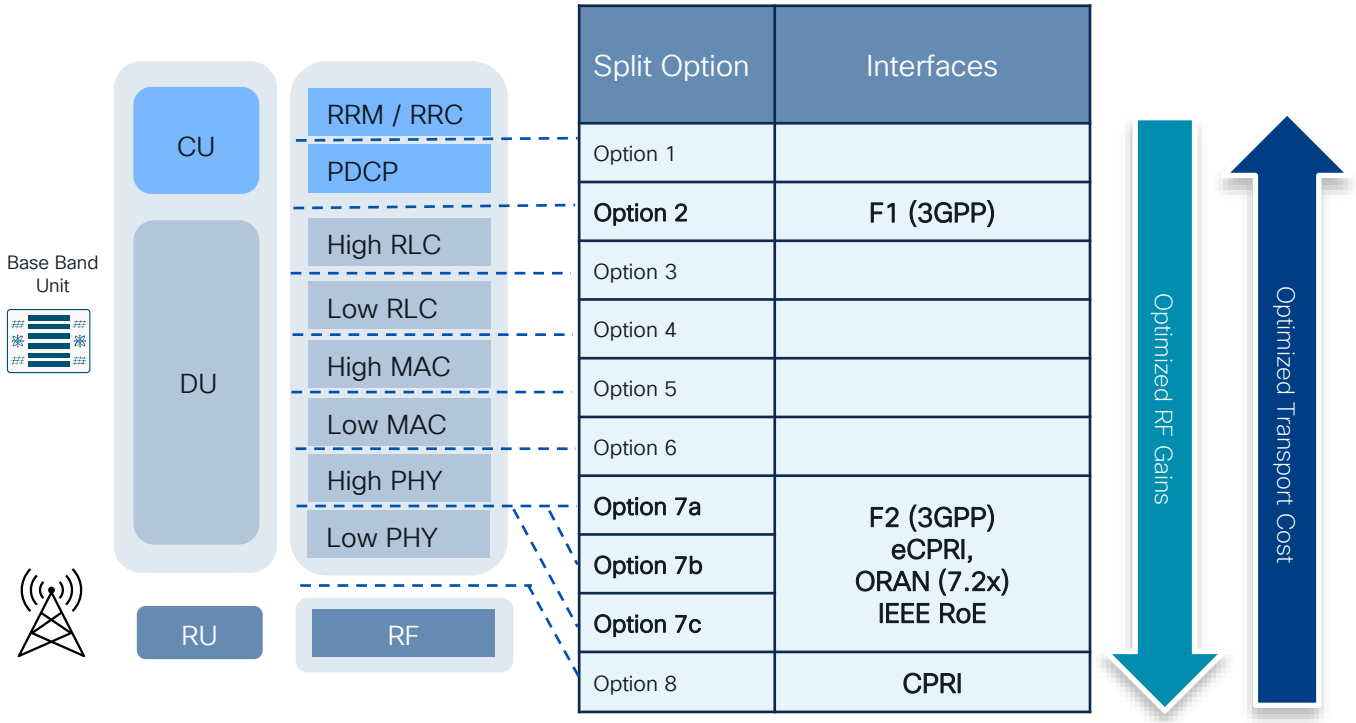
Increased network density



Massive MIMO

RAN Components

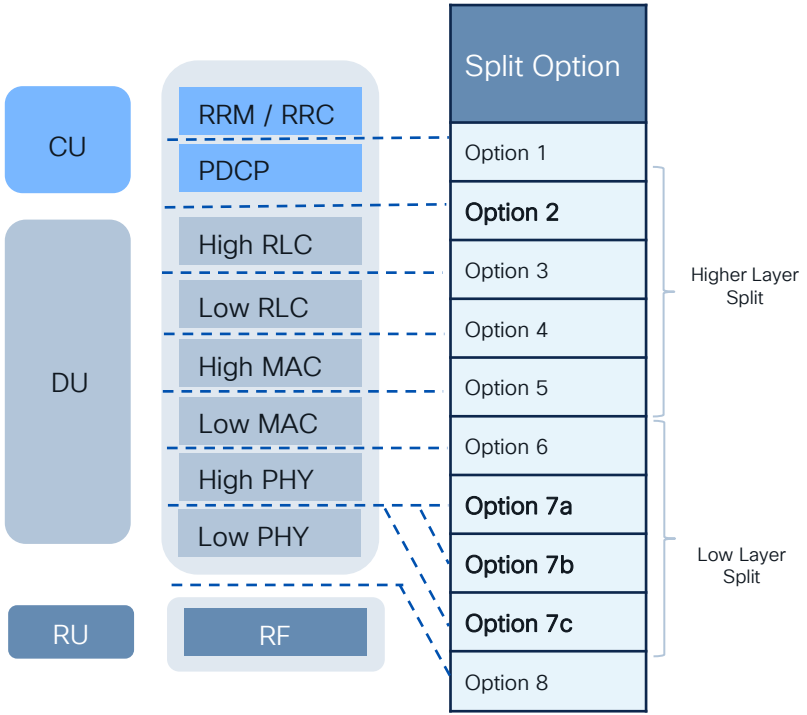




RU: Radio Unit, CU: Centralized Unit, DU: Distributed Unit. BBU: Baseband Unit, CPRI: Common Public Radio Interface, eCPRI: enhance CPRI, RoE: Radio over Ethernet

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Split Benefits

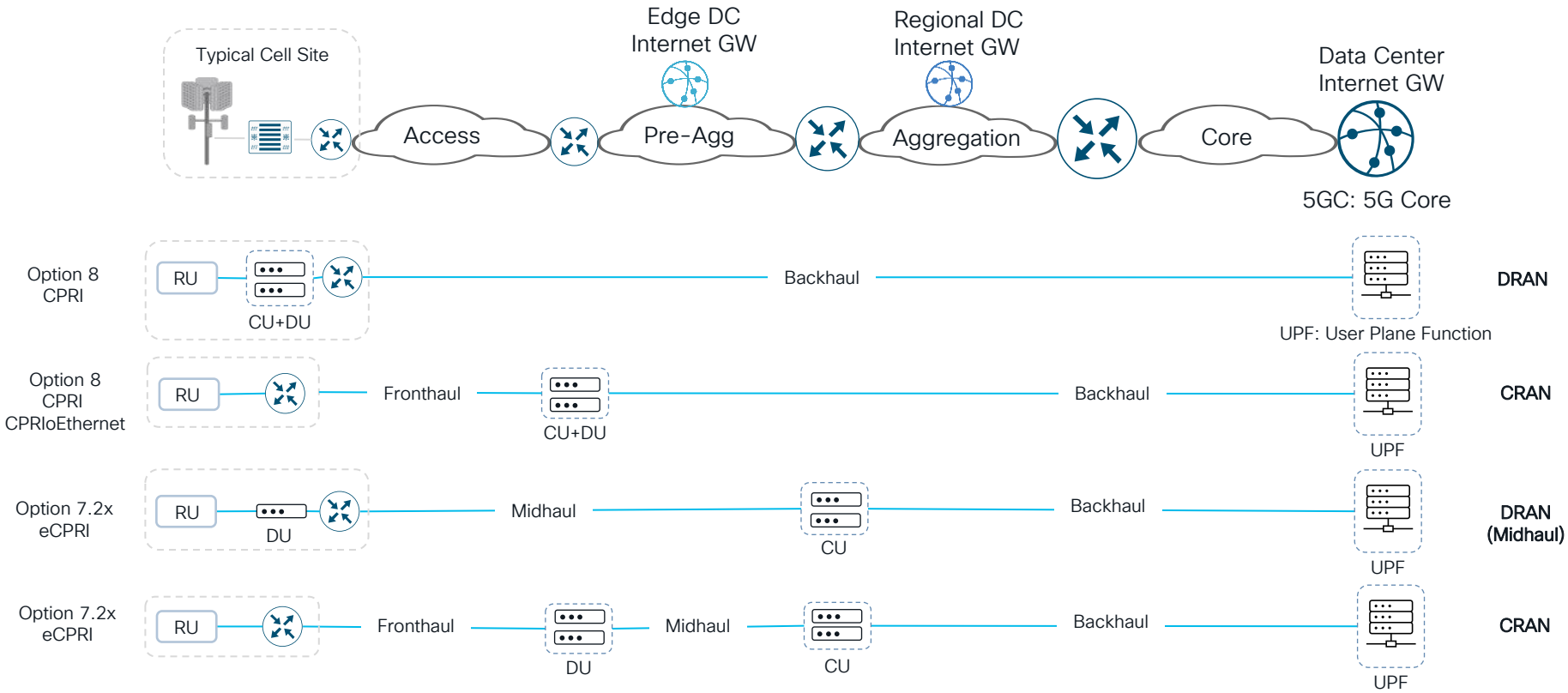


High Layer Split	
Huge transport bandwidth reduction	Coordinated Multipoint (CoMP) is extremely complex
Ideal for Fix Wireless Access (FWA)	Complex and expensive Radio (Size, Cooling, Heat, Cost, Weight)
Relaxed Latency	
Most of processing is integrated in Radio Head	

Lower Layer Split	
Ideal for CoMP, that means mobile applications	High transport bandwidth
Less complex Radio, reduce Cost	More Antenna ports, more transport bandwidth required
	Stringent Latency

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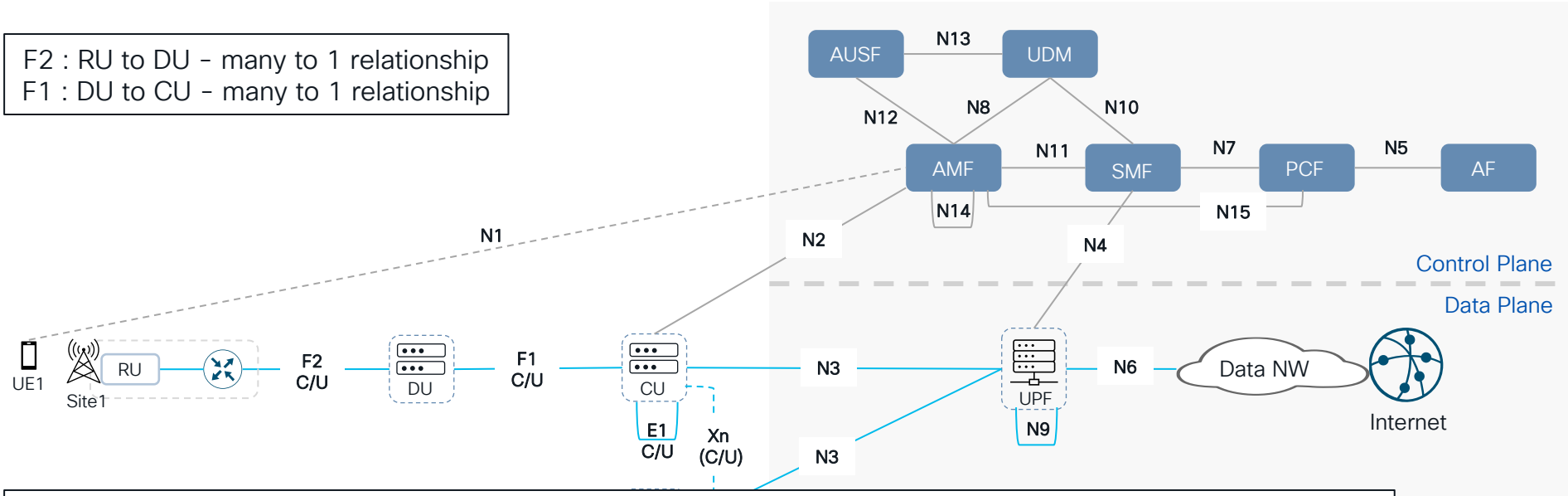
RAN Architecture



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RAN and 5GC Interfaces

F2 : RU to DU – many to 1 relationship
F1 : DU to CU – many to 1 relationship



All interfaces are mandatory IP based (except F2 where its optional)
There is a complex set of networking requirements between different 5G components
1 to 1, 1 to many, many to many
Same component may need to support all models concurrently!

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FH and MH Transport Requirements

Network	Split Options	Transport Latency (One Way)	Distance	Traffic Types & Packet Size
Midhaul (F1)	Option 2: PDCP-RLC	5 ms – 25 ms	> 20KM	F1-U & F1-C (IP) | 500-9K bytes, UE 1500 bytes

Fronthaul (F2)	Split 7 / Option 7.2x: PHY Hi- PHY Lo (Between RU and DU)	• **75 us / 100 us** (HENS)
		• **160 us**
		  ○ *O-RAN.WG4.IOT.0-v03.00 (NR TDD|NR FDD|LTE TDD|LTE FDD IOT Profile)
		• **200 us**
		  ○ ORAN Customer example - 5G NR eMBB
			< 40KM	• User Plane & Control Plane
				  ○ VLAN tagged | 1300-9K bytes
				• Synchronization plane is untagged multicast | <1500 bytes
				• Management plane is IPv6/IPv4 routed |<1500 bytes

Fiber Latency	
5 us / km	Examples: 20 km = 20 x 5 = 100 us 32 km = 32 x 5 = 160 us 40 km = 40 x 5 = 200 us

Latency Number varies with RAN vendor implementation.
Check with with RAN vendor for Fronthaul and Midhaul 4G & 5G transport latency requirement numbers

* Fronthaul Interoperability Test Specification (IOT)

HENS= Huawei, Ericsson, Nokia & Samsung

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Large Cell Site Bandwidth Evolution

Single Cell Site/3 Sector 7 Carriers

Bandwidth per cell site 3 x 205MHz = 615 MHz
Fronthaul NNI Interface Required=100G
Midhaul NNI Interface Required = 25G
Backhaul NNI Interface Required = 25G

Band Number	Band (MHz)	Bandwidth [MHz] per sector	MIMO/MIMO Layers	FH Data Rate In Gbps ("3" Sectors)	Midhaul Bandwidth In Gbps ("3" Sectors with Stat-mux)	Backhaul Bandwidth In Gbps ("3" Sectors with Stat-mux) [20% less overhead]
LTE	800	10	2T2R	.69	.15	.13
LTE	1800	20	4T4R	2.78	.59	.50
LTE	2100	15	4T4R	2.08	.44	.38
LTE	2600	20	4T4R	2.78	.59	.50
LTE	1400	20	2T2R	1.39	.30	.25
NR	1800	20	4T4R	2.94	.43	.37
NR	3500	100	64T64R (16DL8UL)	60.67	8.88	7.55
Total		205 MHz		73.33 Gbps	11.38 Gbps	9.68 Gbps

Compare to average 300 Mbps in LTE cell site

Access Transport Bandwidth: 1G → 10G → 25G
Edge/IP Core Transport Bandwidth: 10G → 100G → 400G
Converged (Wireline + Wireless) Access Transport Bandwidth: 25G → 100G → 400G ZR/ZR+

Statistical Multiplexing (Statmux)=1Max+2 Average
UNI User network interface
NNI Network to Network interface

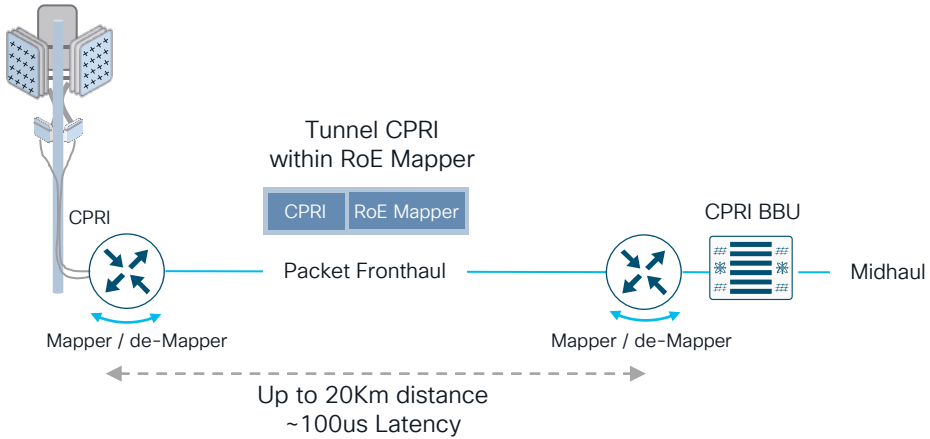
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Brownfield RAN Solution



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CPRI in CRAN Architecture



CPRI over Ethernet for CPRI CRAN deployment

Deployment Modes:

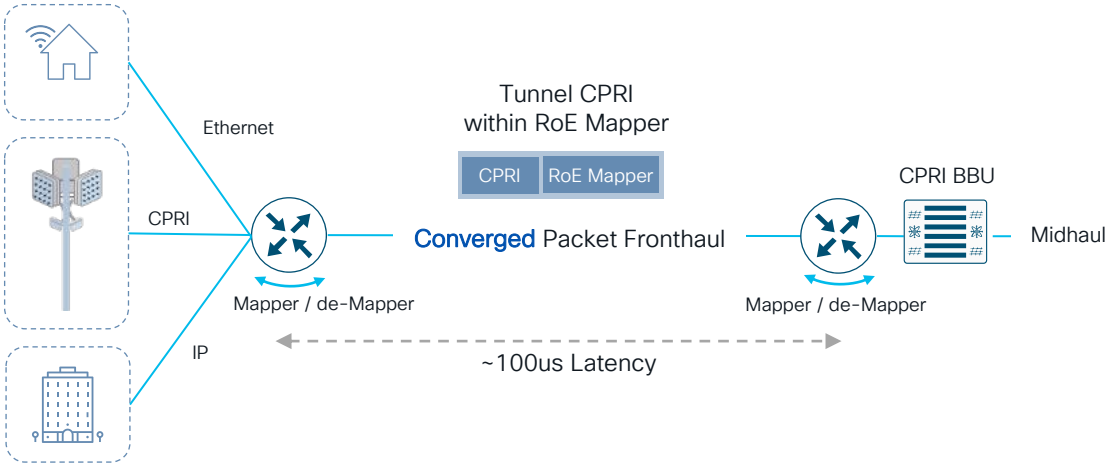
1. RoE Structure-Agnostic Tunneling Mode (Type 0)
   - Compatible with all RAN suppliers' equipment.

2. RoE Structure-Agnostic Line Code Aware Mode (Type 1)
   - Tailored with RAN vendor specific CPRI information to reduce fronthaul bandwidth by 20%.

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CPRI over Converged Packet Fronthaul

IEEE TSN: 802.1Qbu, Frame Preemption Technique



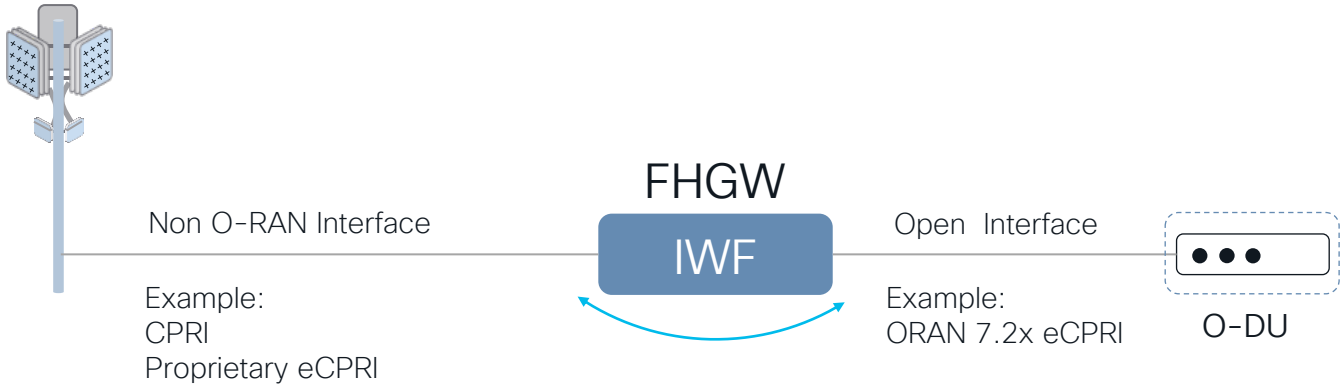
- 8021.Qbu with Strict Priority + Preemption offers lowest fronthaul latency and greatest BW utilization
- Required on uplink 10G or 25G interfaces
- Its book ended, hardware solution.

In -> Out	HP Packet Size	LP Packet Size	802.1bu (w Frame Preemption)		No 802.1bu (wo Frame Preemption)	
			HP Latency (us)	HP Jitter (us)	HP Latency (us)	HP Jitter (us)
10G->25G	1500 (eCPRI)	9K (Enterprise)	17.677 (Saving of 4.34 us)	3.24	22.021	4.54

Saving of 4.34 us = 1Km fiber or 1-Router hop delay

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Fronthaul Gateway

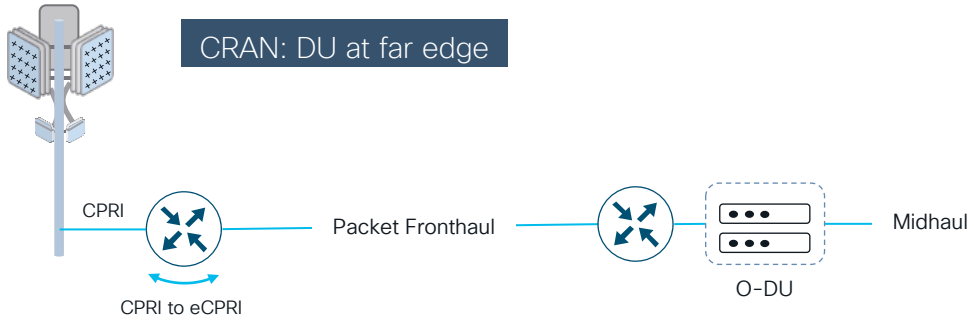


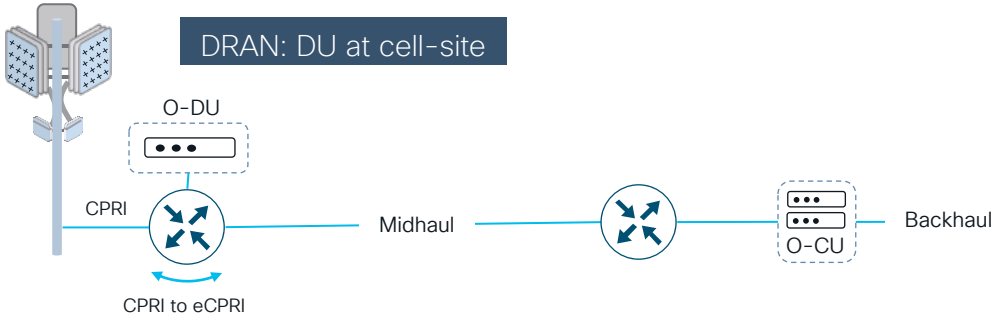
Fronthaul gateway (FHGW) is a RAN function that converts non-ORAN interface to O-RAN 7.2.x Interface

ORAN Alliance defined IWF and Open FHGW HW Platform specification as part of *ORAN.WG7.HRD.0-v02.00.pdf*

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CPRI with FHGW





FHGW
Open Platform
Open SW APIs

Enables Unified Architecture for Brownfield RAN

Optimizes Transport Bandwidth by:
9X

Improved Brownfield Network TCO*
24%

*As per TCO done for an operator

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NCS540-FH Series Routers

N540-FH-CSR-SYS
(Cell Site Router)

N540-FH-AGG-SYS
(Aggregation)



Fronthaul Router	Use Case	Port Config	RU	Capacity	Software
N540-FH-CSR-SYS 	Cell Site Router [Packet + CPRI +TSN]	• 8xCPRI (Option 3-8) + *4x1/10G/CPRI (Option 3-8) • 8x1/10G • 4x10/25G • 2x10/25G (802.1Qbu) • 2x100G *Universal Port = Port can be used for CPRI or eCPRI or Ethernet (1/10/25GE)	1 RU	300Gbps	IOS XR
N540-FH-AGG-SYS 	Aggregate Site Router [Packet + CPRI + TSN]	• 24x10G/25G* • (802.1Qbu, CPRI 3-8) • 4x100G *Universal Port = Port can be used for CPRI or eCPRI or Ethernet (1/10/25GE)	1 RU	900Gbps	IOS XR

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Brownfield Solution Benefits

- Cisco platform supports open standard based solutions:
  - CPRI over Ethernet
  - Fronthaul Gateway

- CPRIoEthernet Supports legacy Radios in CRAN deployment
- FHGW simplify ORAN and virtualization adoption
  - Reduce overall cost and simplify migration
- Cisco Platform offers universal Ports for investment protection

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References

Cisco, Xilinx and Keysight Packet Fronthaul Demo

Innovating the future of Open RAN

Cisco FHGW solution demo at O-RAN Global Plugfest 2021.

Making 5G adoption cost effective for brownfield providers

O-RAN Global Plugfest 2021

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Cisco Converged SDN Transport

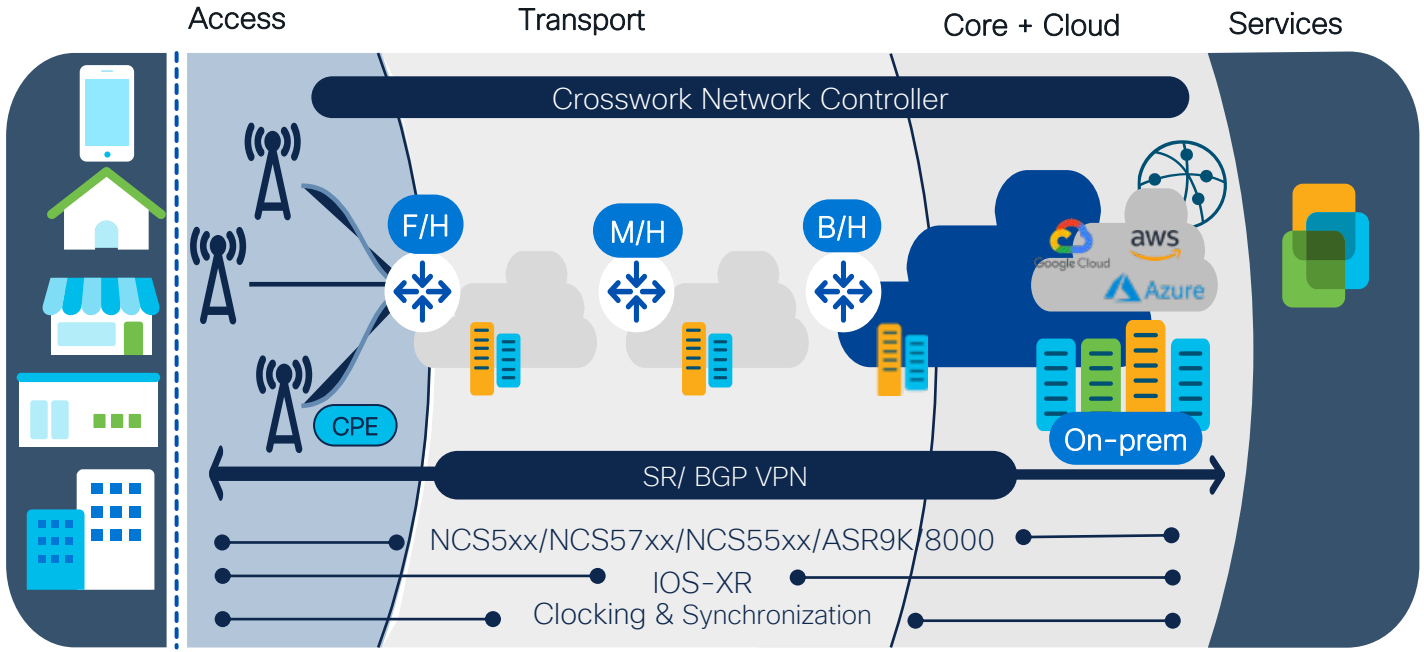


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Cisco Converged SDN Transport

Reduce Infrastructure Costs and Simplify Operations

- Converged Infrastructure for all Services
- Common Technology End-to-end: SR and BGP VPN
- Open, Programmable SDN-based
- On-prem & Cloud-based (Hybrid Cloud)

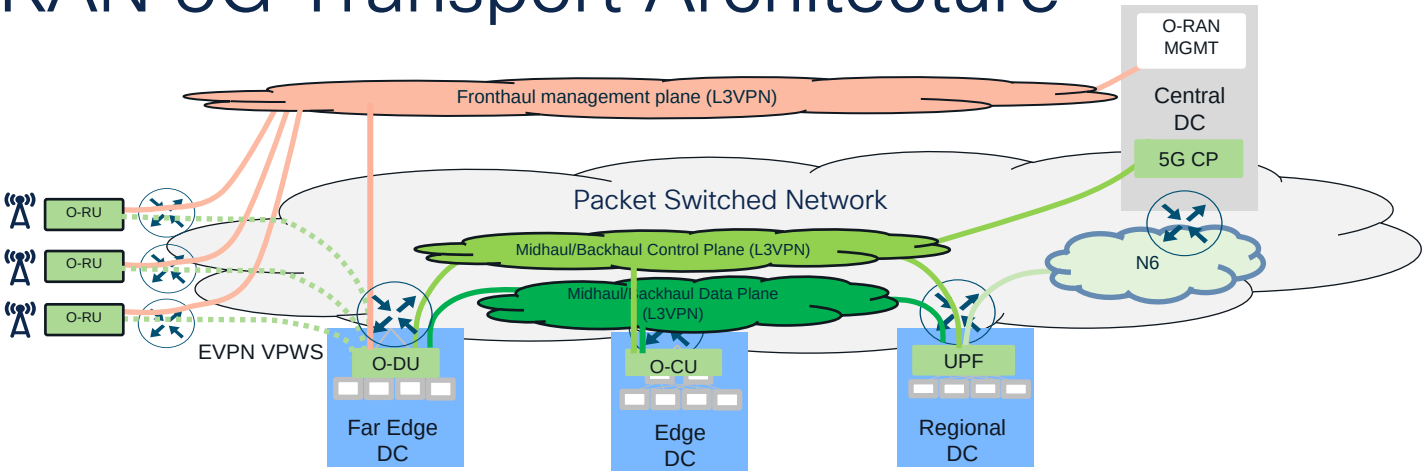


Cisco architecture is validated as per O-RAN WG-9 "Packet Switched Xhaul architecture and solutions"

https://oranalliance.atlassian.net/wiki/spaces/OAH/pages/2124251433/ORAN+Xhaul+Packet+Switched+Architectures+and+Solutions+v2.0

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O-RAN 5G Transport Architecture



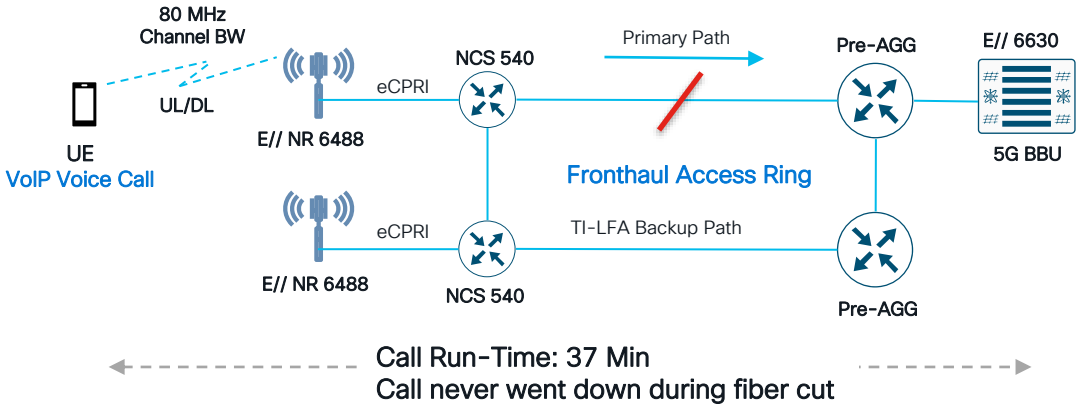
O-RAN WG-9 “Packet switched architectures and solutions” outlines followings:

- 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
  - 4G / 5G mobile broadband share same backhaul VPN infrastructure
- Appropriate packet based QoS and forwarding plane for the 5G service

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5G RAN Resiliency with SR

Case Study: Packet fronthaul network

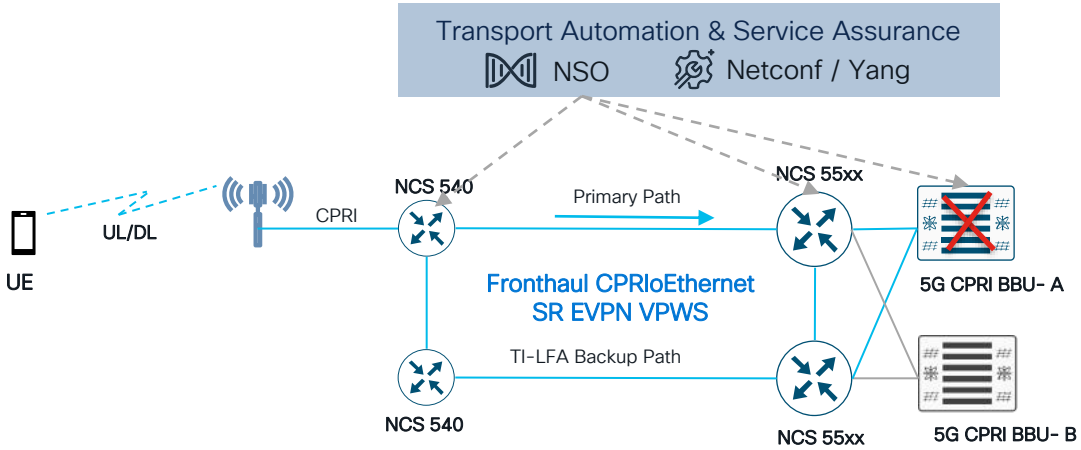


- Fronthaul network between Cisco NCS 540 and E// BBU is approx. 14km
- The setup was running eCPRI between E// NR Radios and BBU (non-ORAN specification of eCPRI)
- TI-LFA is enabled to provider protection against link failures
- No cell went down during the failure and convergence time
- No service issue or call drop observed

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5G RAN Resiliency with Automation

Case Study: Packet fronthaul network



Scenarios:

- Radio CPRI is connected to BBU-A
- When BBU-A fails, move Radio CPRI connection to BBU-B.

- NSO replicated Radio specifics from BBU-A to BBU-B
- NSO updated VPWS service model to move active CPRI connections to BBU-B
- ConfD translator is used between NSO and BBUs to comfortably integrate RAN vendor BBU
- Automation improved Service provisioning time to 5 minute; from 30+ minute earlier.

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Cloud-Ready Converged SDN Transport

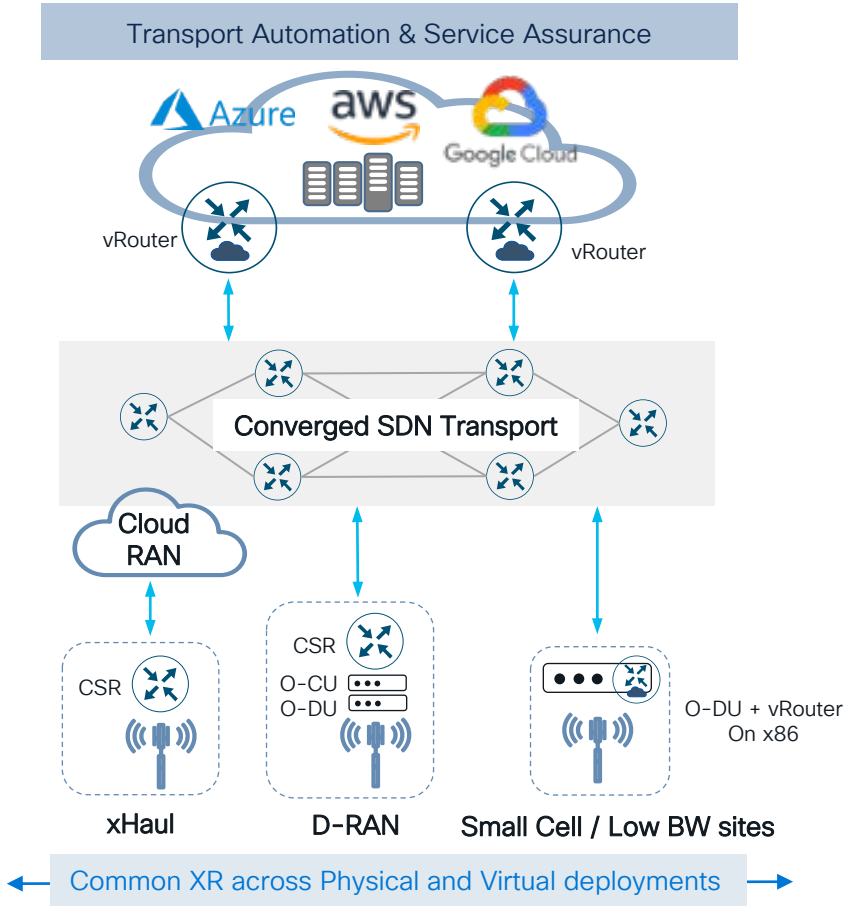


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Cloud-Ready Converged SDN Transport

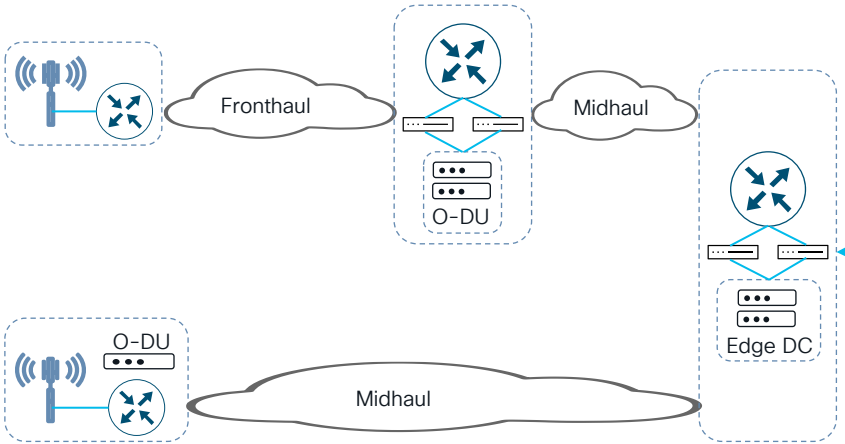
Cisco's 5G Converged SDN Transport is extended to support public & private cloud infra and cloud service availability

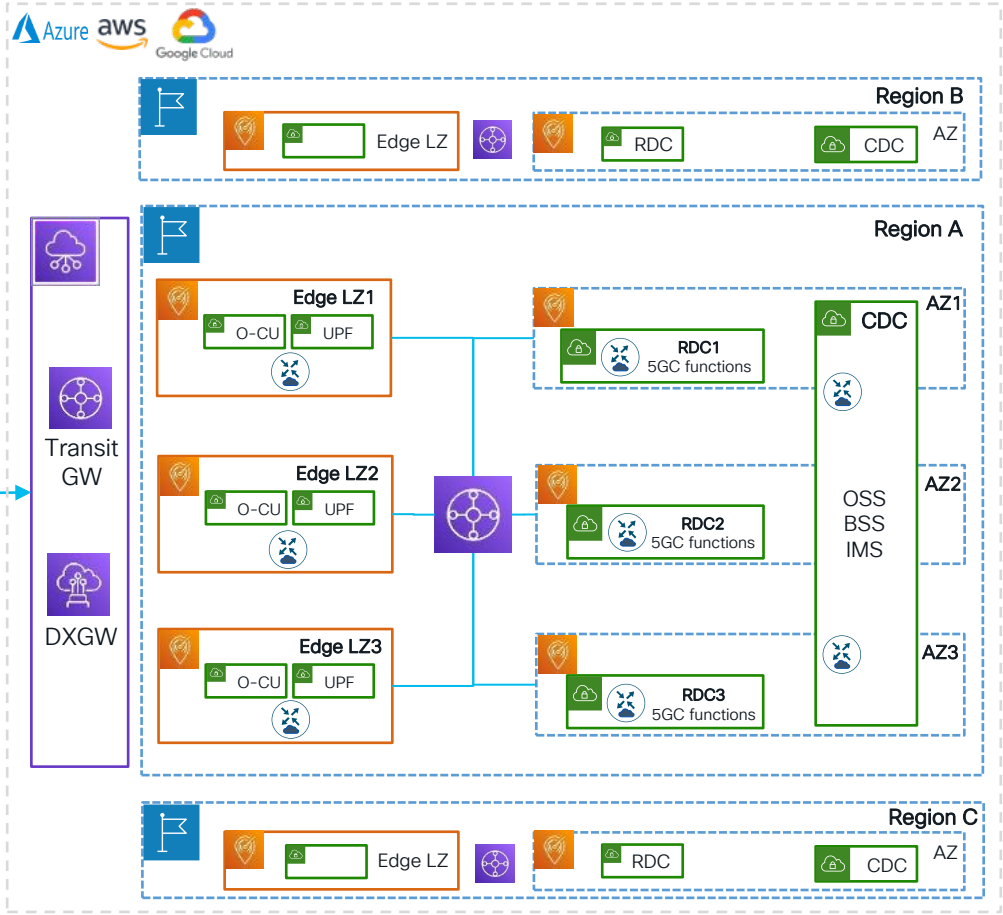
- End to End SR with Slicing
- vRouter functions:
  - XRv9k as VNF
  - XRd as CNF
- vCSR integrated with vDU server for low bandwidth sites
- Automation and Service Assurance



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CSP Hybrid Cloud



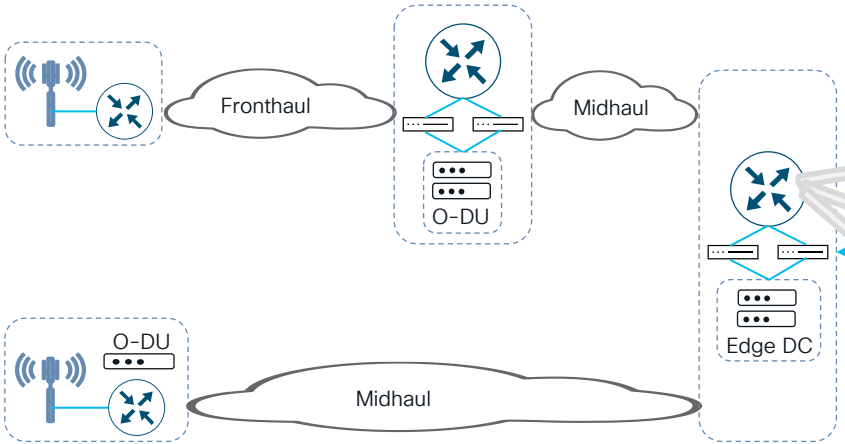


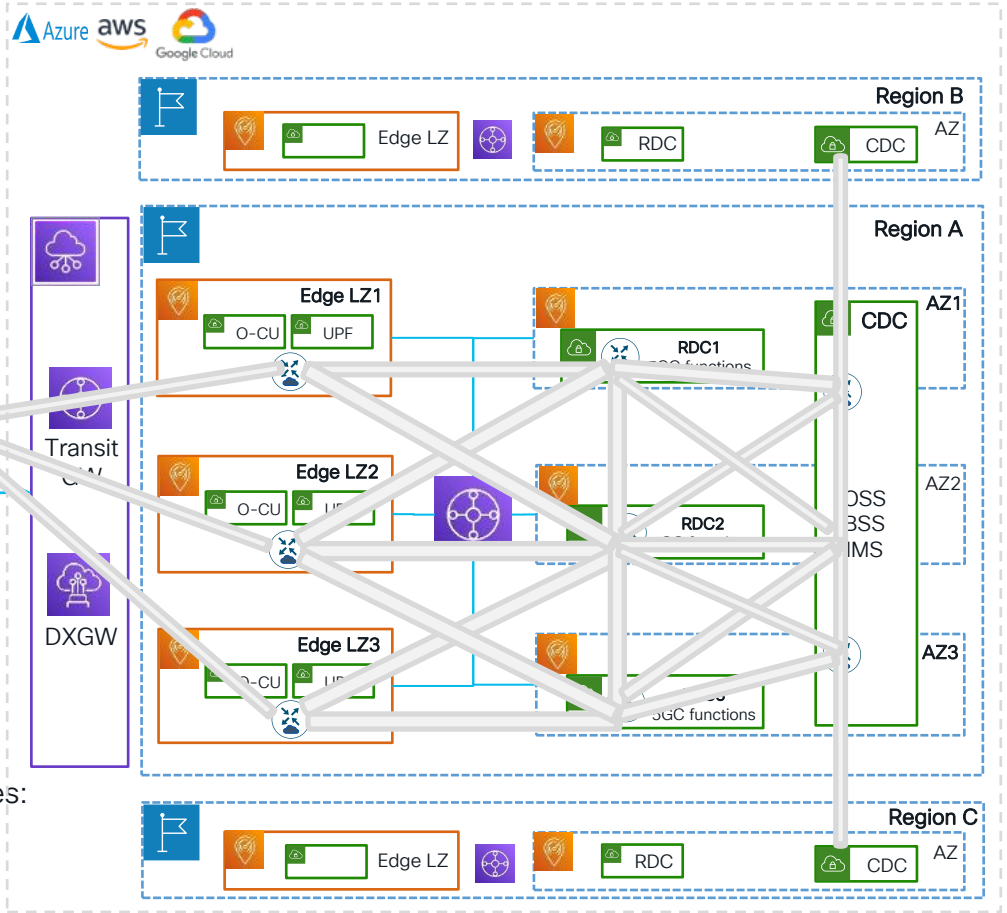
- CSP corporate IT moving to public cloud
- Most of the content delivery is part of public cloud
- 5G RAN and 5GC services are part of Hybrid cloud

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CSP Hybrid Cloud

Public Cloud Provider Solution





- 5G RAN and 5G Core require connectivity for various services:
  - Voice, Enterprise, Network slicing etc.
- L3 VPN, Anycast & BGP extension to VPCs
- GRE is currently available option for overlay architecture
- Alternate options with IPv6 / SRv6 are under discussion

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Cisco Cloud Native Router

Software based router to run on x86



- Cisco IOS-XR and Management
- DPDK/VPP based forwarding
- Kubernetes compliant
- Light footprint on x86 compute

Solution for Cloud native deployments



- Suitable for Cloud native environments
- Routing function at low-bandwidth cell site
- Physical CSR Feature parity

CPU Cores	2 physical cores: 1 for control plane ; 1 for dataplane (*)
Memory	11 GiB: 8 GiB regular memory + 3 GiB huge pages (**)
Disk	7 Gb (***)
Boot time	~2 mins (to BGP convergence)
Latency	50us via vRouter CNF
Performance	Intel Ice Lake CPU @3.5 GHz turbo, Packet size 1514 bytes ~ 56 Gbps – IPv4 Only ~ 47 Gbps – Customer config (L3 VPN, SR/MPLS, ECMP VLAN with egress QoS)

* CPU may require hyperthreading for control plane stability

** 11 GiB provides equivalent memory to NCS540
- 8 GiB is minimum to boot
- Real configuration expected to be < 10 GiB

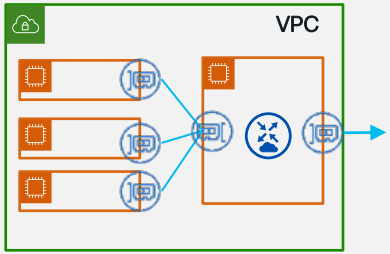
*** Includes provision for logs and other operational data; in most cases usage <= 2Gb

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Simplification with Cloud Native Routing

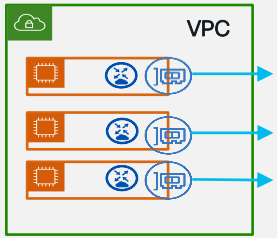
Cloud Networking

Traditional vRouter



Inter-subnet communication within VPC or inter-VPC communication happens via vRouter

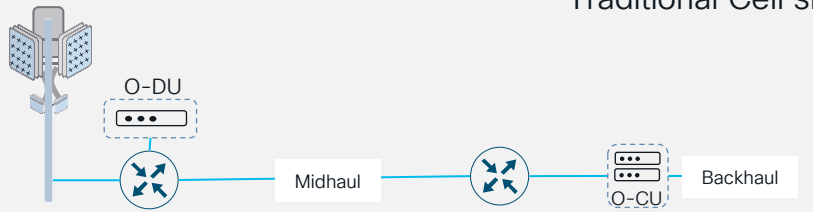
Cloud Native vRouter



Distributed Routing simplify the routing architecture

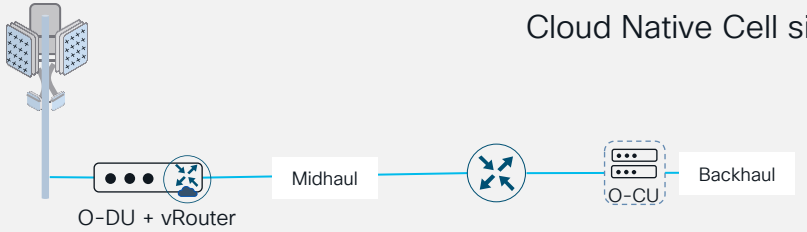
Cell-site Networking

Traditional Cell site



Cell site Router provides transport connectivity to cell site

Cloud Native Cell site



Cloud native routing is expected to optimize inventory and power at low-bandwidth cell site.

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Key Takeaways!!

Cisco *Cloud-Ready Converged SDN Transport* provides solution to address:



- Brown-field deployment of 5G RAN with CPRIoEthernet and FHGW based solutions



- SR / SRv6 for Resiliency and Redundancy to 5G RAN services



- End to end automation and service provisioning

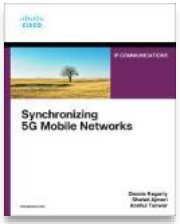


- Seamless deployments of cloud-native functions within hybrid cloud environments

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References!

- 5G Timing Synchronization
  - *BRKSPM-3295: 5G Time Synchronization, Cisco Live 2020*
  - *BRKSPG-2557: 5G Synchronization – Design, Testing and Deploying Timing to support 5G rollouts*



  - *Cisco Press Book: Synchronizing 5G Mobile Networks by:*
  - *Dennis H, Shahid A, Anshul T*

- Cisco 5G SDN Transport Products:
  - *Cisco Converged SDN Transport*

- Other Sessions:
  - *BRKSPM-2003: Building Service Provider Access and Pre-Agg Networks with NCS 500 Series*
  - *BRKSPM-3169: Customer Challenges and Practical Design Consideration for 5G Transformation*
  - *BRKSPM-3169: Customer Challenges and Practical Design Consideration for 5G Transformation*
  - *BRKSPM-1005: MEC Enablers for 5G Networks*
  - *BRKSPM-2842: Industry enablers making Private 5G viable private networking options*

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