Designing Cloud RAN Cell Sites with Red Hat OpenShift

Service Provider Tech Talk Series
Feb 9, 2022

Kashif Islam, Principal Telco Architect
Syed Hassan, Principal Telco Architect

Red Hat

Agenda

▸ Cell Sites in a Cloud RAN Era

▸ Placement Considerations for Cloud RAN Components

▸ Red Hat OpenShift : The Cloud Platform for Cloud RAN

▸ Timing and Synchronization Considerations

▸ Summary

Cloud RAN – A Quick Recap of Characteristics

Decomposed
- Splitting the BBU and RRU functions into:
  Radio Unit (**RU**), Distributed Unit (**DU**) & Centralized Unit (**CU**)
- Various options to split the functions defined by 3GPP and others

Disaggregated
- RAN software disaggregated from custom hardware
- Allows virtualization, especially of the DU **(vDU)** and CU **(vCU)**

Cloud Native
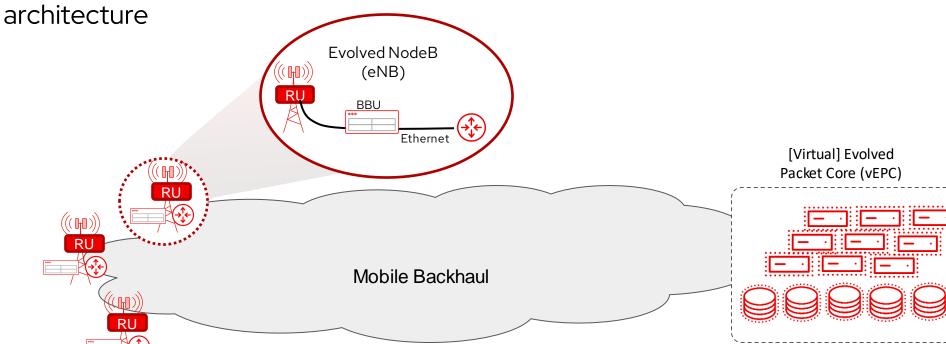- DU and CU software functions are virtualized to be cloud-native (containers, microservices, etc)

Cloud RAN
- vRAN architecture where the vDU/vCU are cloud-native
- By definition, a subset of vRAN
- Not necessarily hosted on Public Cloud

Red Hat

Legacy RAN Architecture (4G)

▸ Cell Site (eNB) comprises:

- Antenna

- Remote Radio Unit (RRU/RU) close to the Antenna
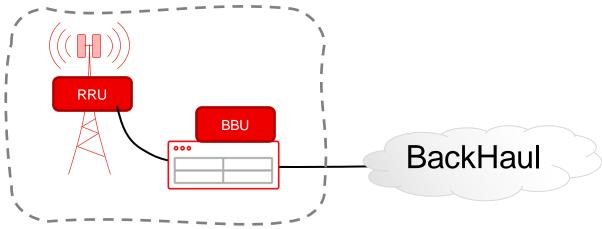
- Baseband Unit (BBU)

- Cell Site Router (CSR)

▸ Typically collocated at the Cell Site, but BBU could be moved away i.e a Centralized RAN architecture
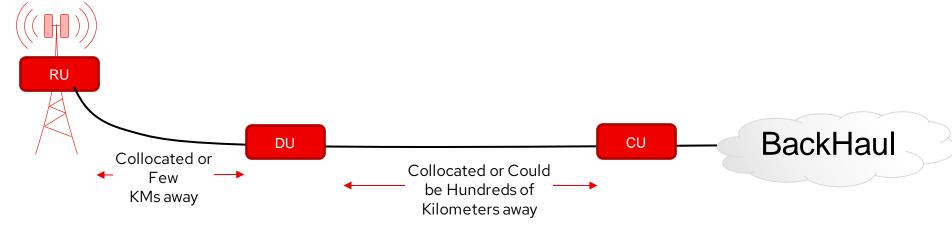

Evolved NodeB (eNB)

RU

BBU

Ethernet

[Virtual] Evolved Packet Core (vEPC)

RU

RU

RU

Mobile Backhaul

Legacy RAN Architecture → Decomposed RAN

Traditional 4G Cell Site

RRU

BBU

BackHaul

Decomposed RAN

RU

DU

CU

BackHaul

Collocated or Few KMs away

Collocated or Could be Hundreds of Kilometers away

Legacy RAN Architecture → Cloud RAN

Traditional 4G Cell Site

RRU

BBU

BackHaul

Cloud RAN

RU

vDU
OCP

vCU
OCP

BackHaul

Collocated or
Few
KMs away

Collocated or Could
be Hundreds of
Kilometers away

Red Hat
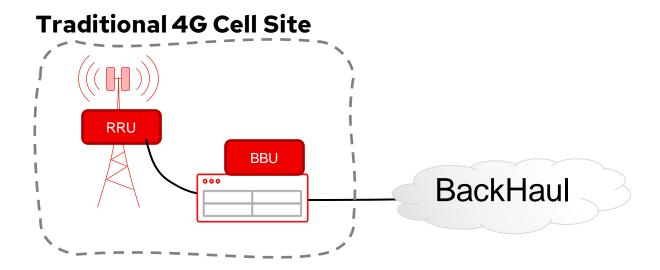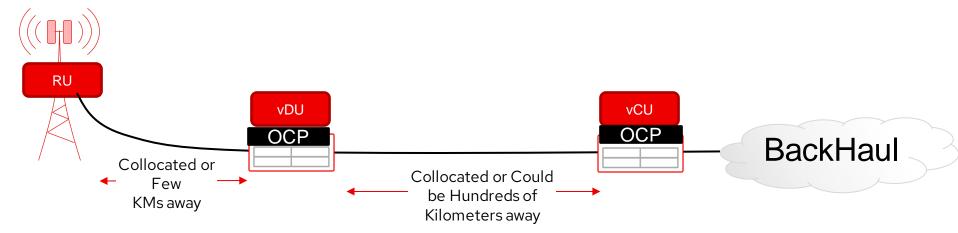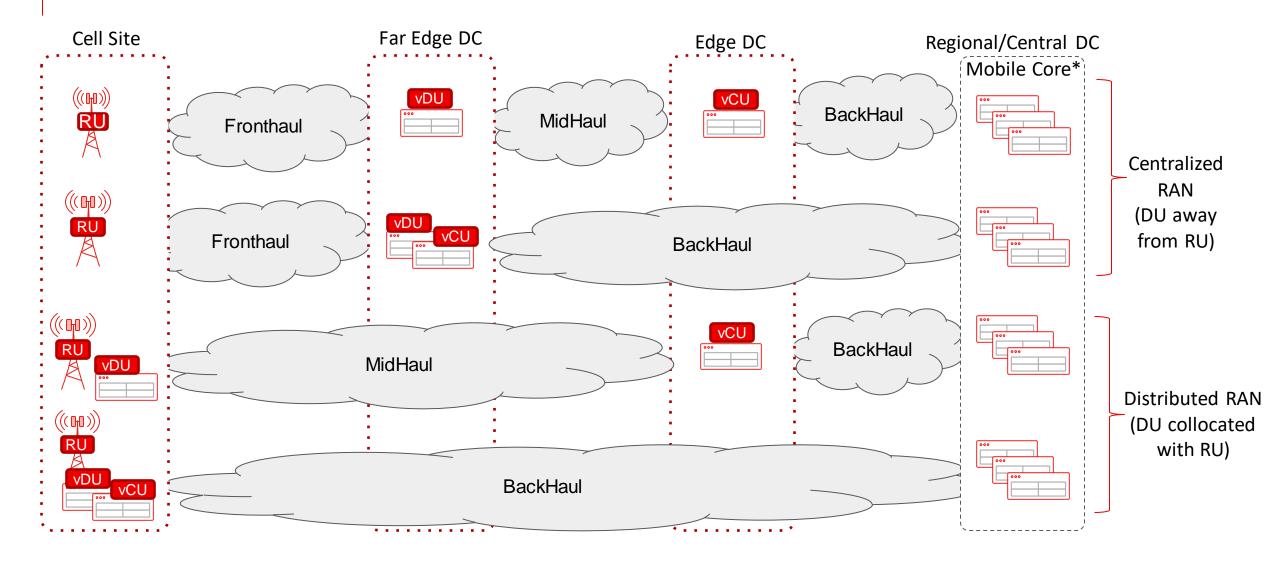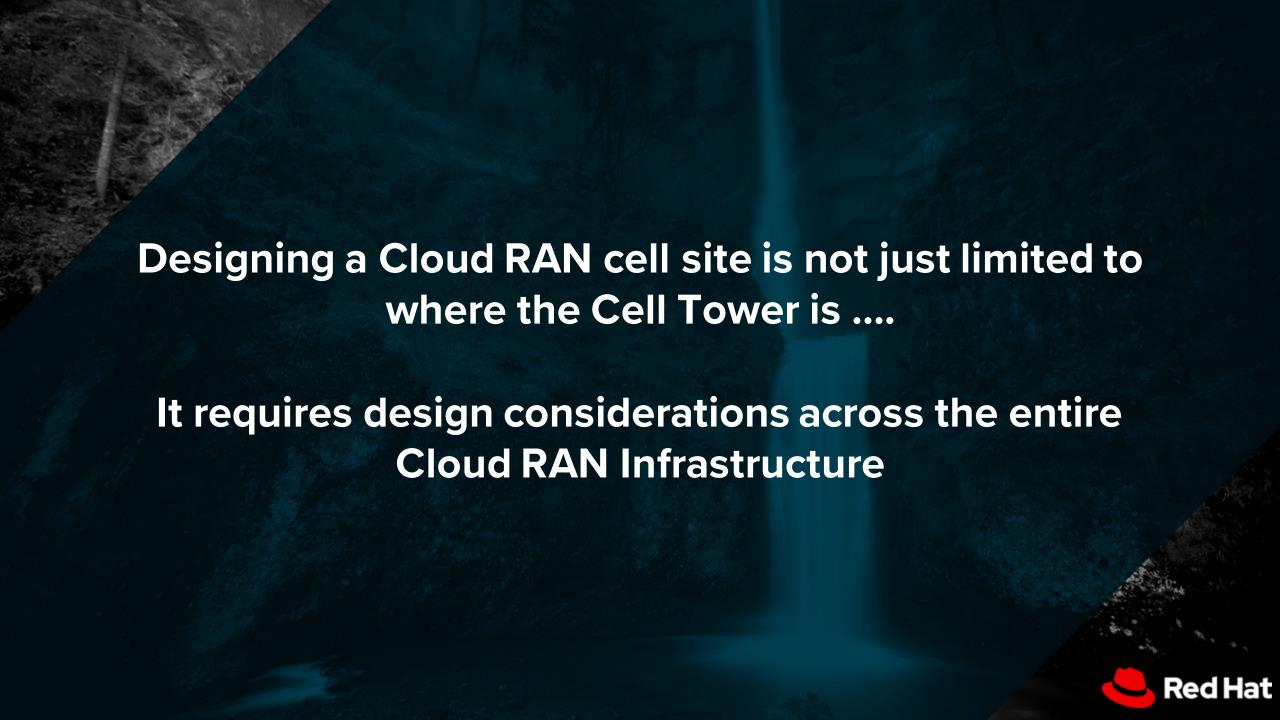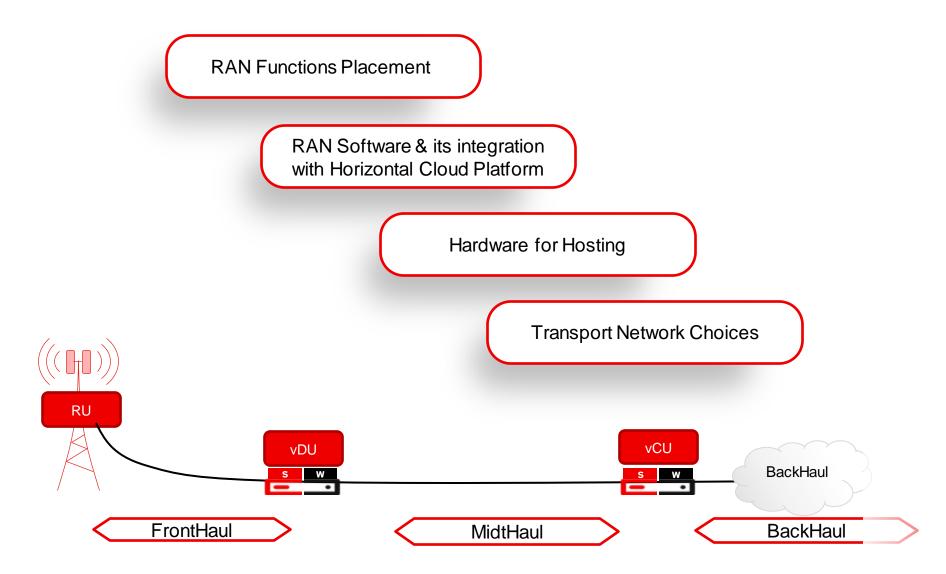
Virtual/Cloud RAN Functions' Placement Options

Cell Site | Far Edge DC | Edge DC | Regional/Central DC

RU — Fronthaul — vDU — MidHaul — vCU — BackHaul — Mobile Core*

Centralized RAN (DU away from RU)

Distributed RAN (DU collocated with RU)

*Some Mobile Core components (such as UPF) can be moved closer to the subscriber and placed a the Edge DC collocated with the CU as part of Control Plane User Plane Separation (CUPS)

Designing a Cloud RAN cell site is not just limited to where the Cell Tower is ….

It requires design considerations across the entire Cloud RAN Infrastructure

Red Hat

Design Considerations for Cloud RAN

RAN Functions Placement

RAN Software & its integration with Horizontal Cloud Platform

Hardware for Hosting

Transport Network Choices

RU

vDU

s w

vCU

s w

BackHaul

FrontHaul

MidtHaul

BackHaul
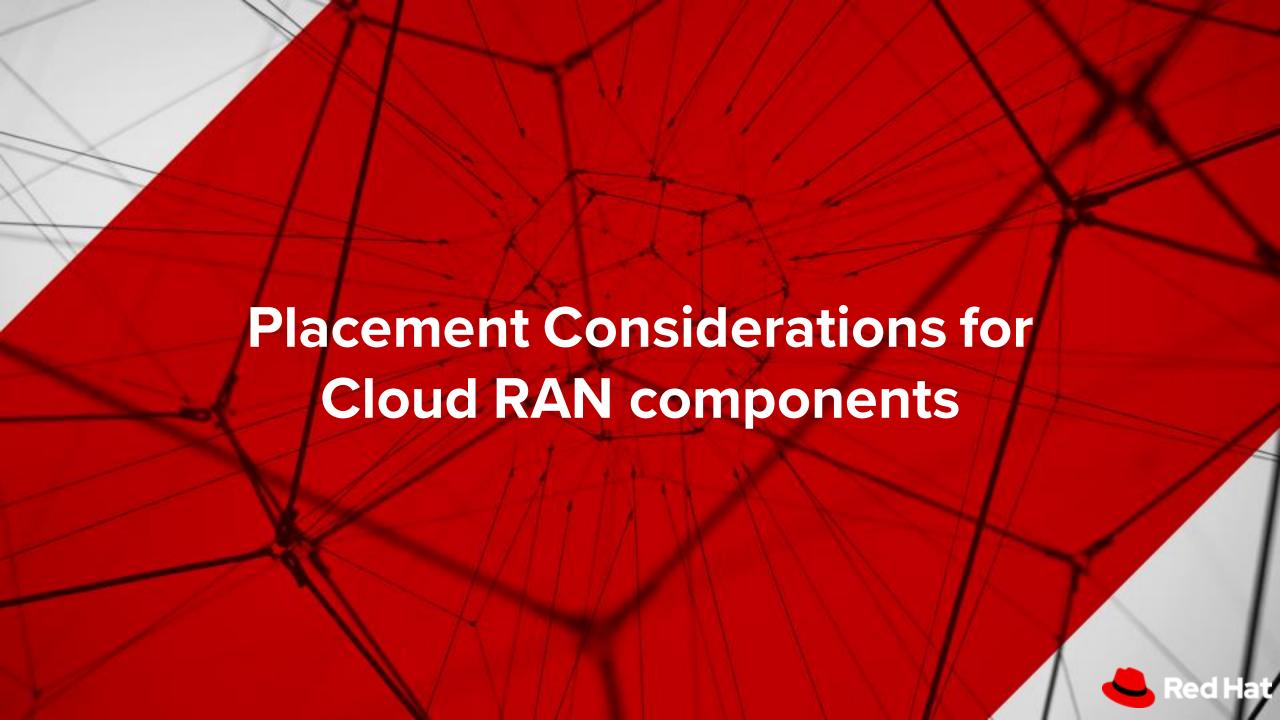
Red Hat

Placement Considerations for Cloud RAN components

RAN Functions Placement Options

vCU

- Typical deployments will have vCU away from cell site (at Edge DC)

  - Can also be deployed at Cell site, or collocated with DU

- May be co-hosted with other applications such as:

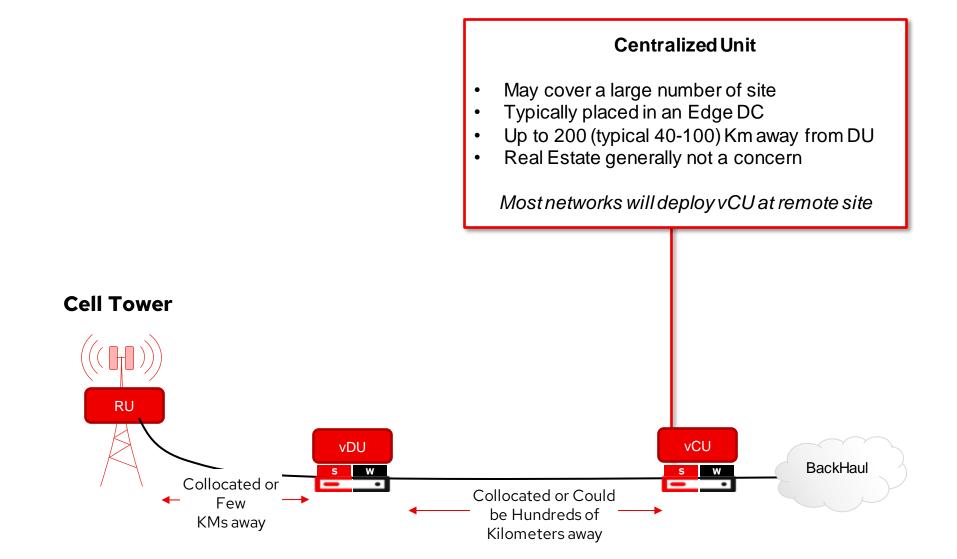 - 5GC User Plane Function (UPF) , Multiaccess Edge Compute (MEC), Content Delivery servers (CDN) etc.

vDU

- Both "DU at Cell Site" and "DU not at Cell site" models being deployed

- Usually not collocated with vCU
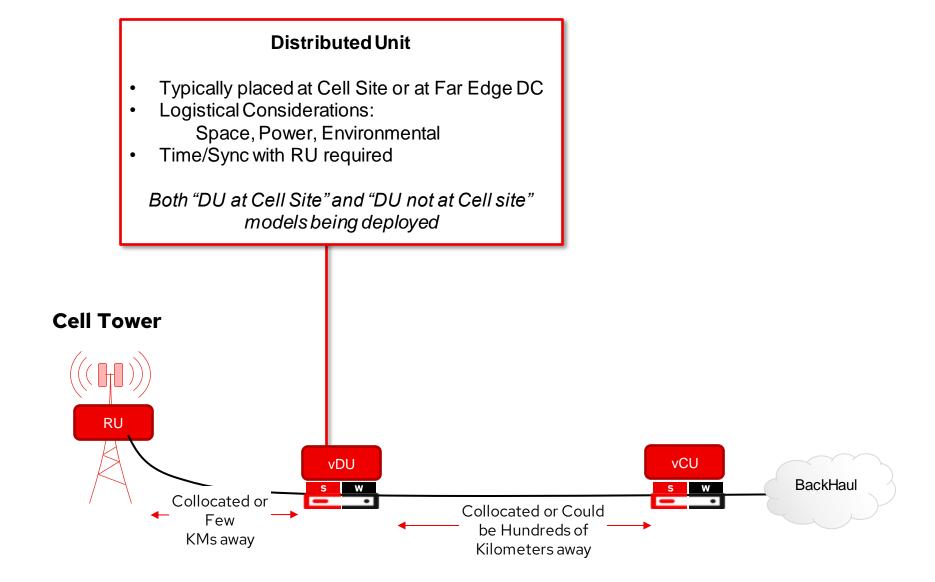
RU

- Always placed at the cell tower

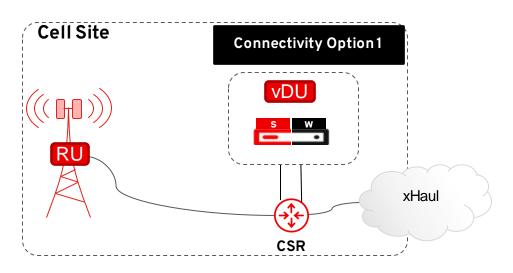Red Hat

Decomposed RAN Components – **CU** placement considerations

Centralized Unit

- May cover a large number of site
- Typically placed in an Edge DC
- Up to 200 (typical 40-100) Km away from DU
- Real Estate generally not a concern

Most networks will deploy vCU at remote site

Cell Tower

RU

vDU

S   W

vCU

S   W

BackHaul

Collocated or Few KMs away

Collocated or Could be Hundreds of Kilometers away

Decomposed RAN Components – **DU** placement considerations

Distributed Unit

- Typically placed at Cell Site or at Far Edge DC
- Logistical Considerations:
  Space, Power, Environmental
- Time/Sync with RU required

Both "DU at Cell Site" and "DU not at Cell site" models being deployed

Cell Tower

RU

vDU

vCU

BackHaul

Collocated or Few KMs away

Collocated or Could be Hundreds of Kilometers away
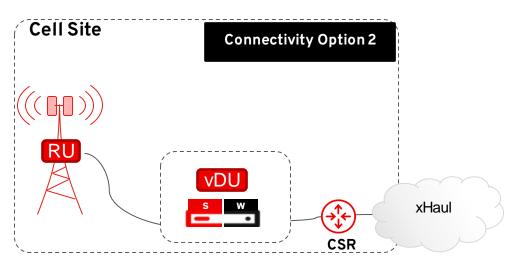
DU **at** the Cell Site: Connecting Cell Site Router, DU and RU

| RU ← → CSR ← → DU	RU ← → DU ← → CSR
Future proof Port density	Suitable for sites with few connections between RU-DU
Relatively lower price per port on CSR	Typically higher price per port on the server hardware
Support Legacy RUs w/CPRI using a FHGW or newer RUs with eCPRI	Newer RUs only that use eCPRI natively
DU can be either Ordinary Clock (OC), Grand Master (GM) or Boundary Clock (BC)	DU needs to be either GM or act as BC
No connectivity change if DU is moved to away from Cell Site	Moving DU away from Cell Site requires physical connectivity change
Configuration complexity (EVPN/L2VPN etc.)	Simpler and familiar design, Easier setup
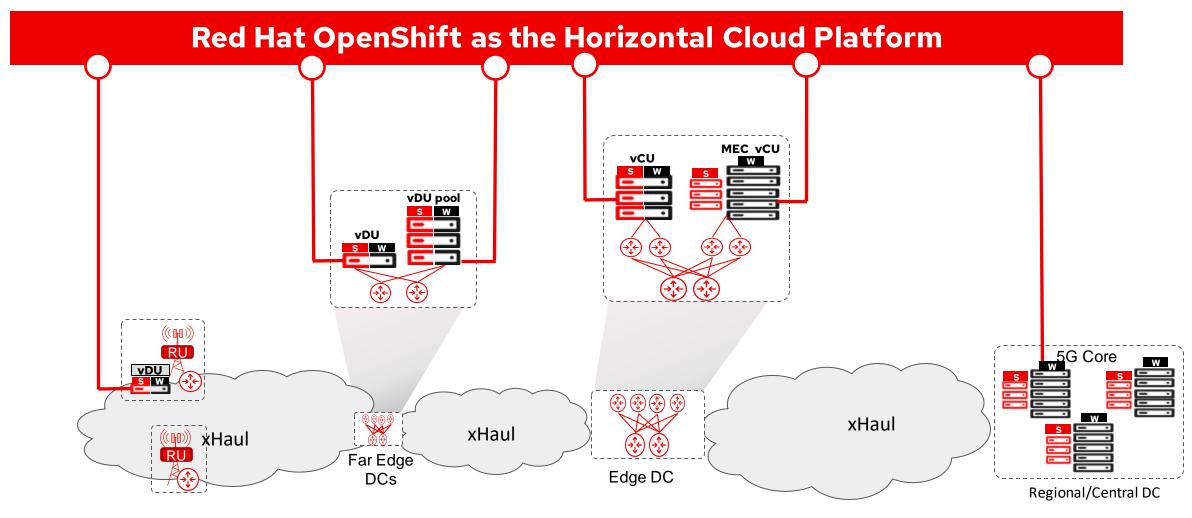
DU **not at** the Cell Site

- Availability of a site to host DU pool

- Can not be more than 20 km from the Cell Site

- Topology considerations to minimize latency and maximize bandwidth of Fronthaul network

- Challenging to host in Public Cloud due to distance and special hardware requirements

- FrontHaul can be a packet or optical network

Red Hat OpenShift as the Horizontal Cloud Platform

vDU pool

vDU

vCU

MEC vCU

RU

vDU

RU

xHaul

Far Edge DCs

xHaul

Edge DC

xHaul

5G Core

Regional/Central DC

Red Hat OpenShift:
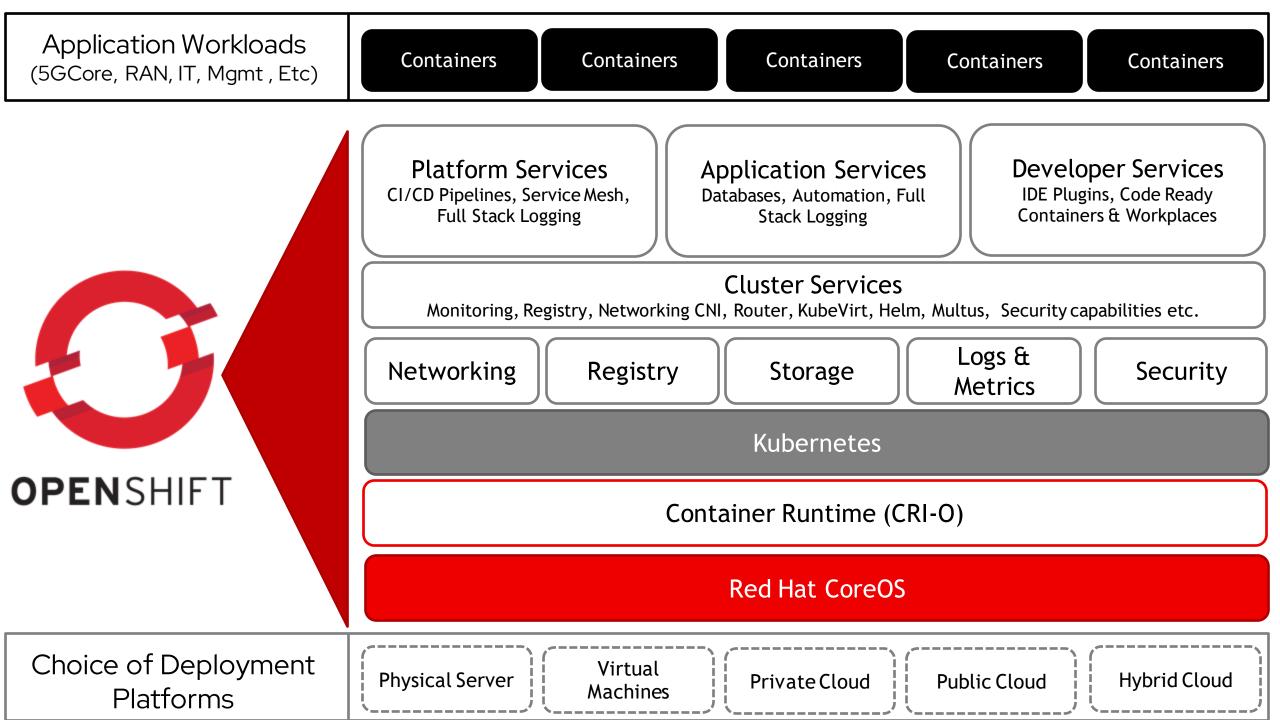## *The* Cloud Platform for Cloud RAN

OpenShift as the Cloud Platform for RAN

- Red Hat OpenShift is Kubernetes !!!

- Red Hat OpenShift is Flexible, Extensible, Scalable, Consistent, and Reliable

- Ready for Cloud-Native RAN workloads i.e. vCU and vDU

- Ability to adjust performance profiles required for RAN applications

  - RT Kernel, Huge Pages, NUMA pinning, and more

- Ability to run on variety of underlying infrastructure

  - Baremetal, Virtual Machines, On-Prem, Public Cloud

- A robust partner ecosystem !!!

This is not an exhaustive list of every Operator available on Openshift

OpenShift Operator Framework for Telco Workloads

- OpenShift operator framework to provide features and functionality

- Full range of OpenShift operators for Telco workloads such as CU and DU.

- Some of the noteworthy operators include:

  - Performance Add-On (PAO) Operator: Performance tuning

  - SR-IOV: Configure and manage SR-IOV for the node

  - Precision Time Protocol (PTP) : Used for Timing and Sync

  - OpenShift Logging Operator: Export Logs

  - Local Storage: Provides persistent storage

  - Intel FEC Operator: Hardware acceleration

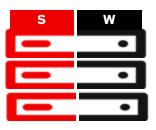This is not an exhaustive list of every Operator available on Openshift

Red Hat

Red Hat OpenShift Formfactors

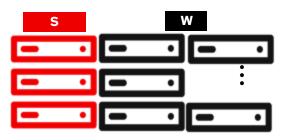## Single Node OpenShift (SNO)

Real Estate Optimized

Large Scale Access Deployment

3-Node Compact Cluster

Redundancy and High Availability

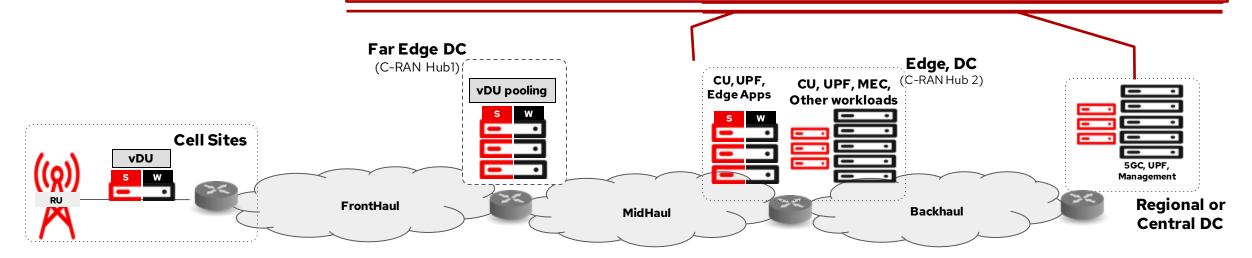**Edge Optimized**

Traditional Multi-Node Cluster

Scalable & extensible

Highly redundant
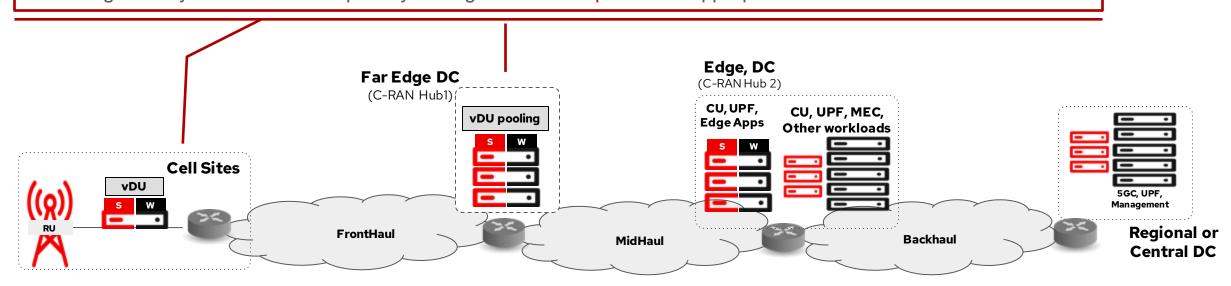
OpenShift Cloud Platform for v**CU**

- CUs at a single site may control a sizeable number of cell sites

- May require multiple compute nodes for scale and redundancy

- 3-node compact or, more likely, multi-node cluster with several worker nodes used based on scale dimensioning

Far Edge DC
(C-RAN Hub1)

vDU pooling

S W

Edge, DC
(C-RAN Hub 2)

**CU, UPF,
Edge Apps**

**CU, UPF, MEC,
Other workloads**

S W

Cell Sites

vDU

S W

RU

5GC, UPF,
Management

**Regional or
Central DC**

FrontHaul

MidHaul

Backhaul

OpenShift Cloud Platform for v**DU**

- When DU at Cell Site: **Single Node OpenShift (SNO)** suffices as DU serves small number (or single) site

- When DU is at Far Edge DC: **3-Node Compact** (or even **Multi-node**) cluster for scale & redundancy

- DU Applications require Hardware Acceleration for Baseband processing

- Timing and Synchronization capability through the PTP Operator & appropriate NICs

Far Edge DC
(C–RAN Hub1)

Edge, DC
(C–RAN Hub 2)

vDU pooling

S   W

Cell Sites

vDU

S   W

RU

FrontHaul

MidHaul

**CU, UPF,
Edge Apps**

S   W

**CU, UPF, MEC,
Other workloads**

Backhaul

**5GC, UPF,
Management**

**Regional or
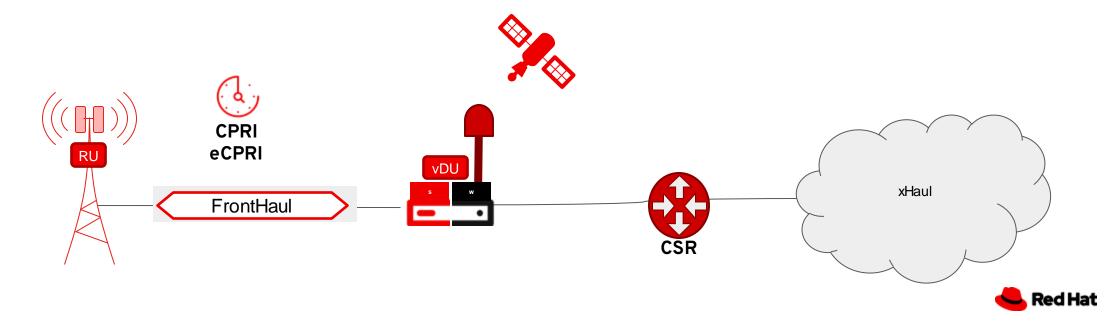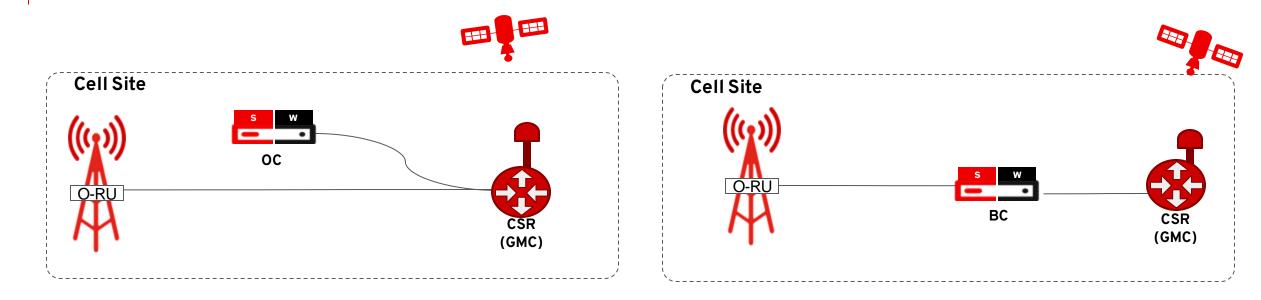Central DC**

Timing & Synchronization

Why is Timing Critical in Cloud RAN?

- RU and DU must be synchronized

- Sync planning is critical in 5G Cloud RAN not only due to advanced radio features, but also due to the different nature of legacy CPRI and eCPRI

- CPRI: Synchronization and timing information inherently carried due to CBR nature

- eCPRI: Relies on packet-based timing and sync techniques (such as PTP)

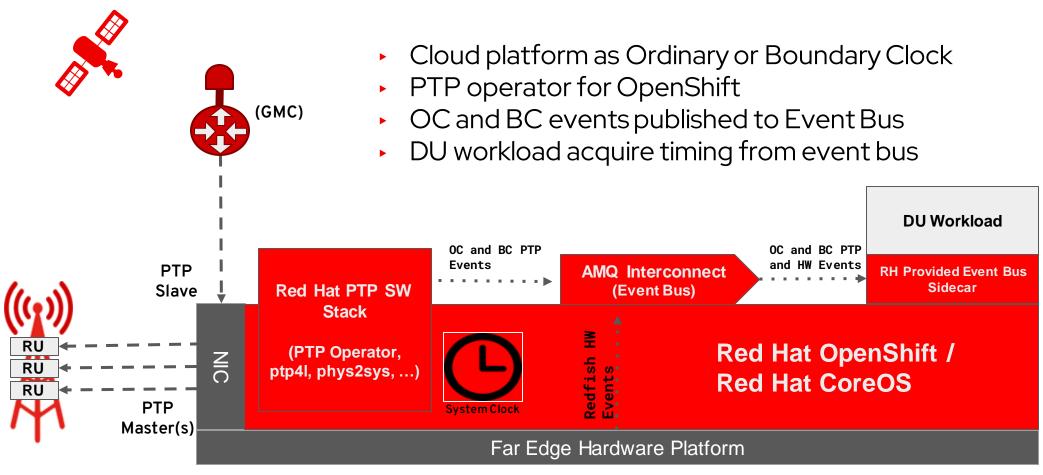# Various Timing and Sync Acquisition and propagation options

- ‣ OpenShift as the Cloud platform for DU can act as OC or BC
- ‣ Clocking can be acquired on 1 or more NIC and propagated to the RUs

GMC : Grand Master
BC : Boundary Clock
OC: Ordinary Clock

Timing in OpenShift

- Cloud platform as Ordinary or Boundary Clock
- PTP operator for OpenShift
- OC and BC events published to Event Bus
- DU workload acquire timing from event bus

(GMC)

PTP Slave

PTP Master(s)

RU
RU
RU

NIC

Red Hat PTP SW Stack

(PTP Operator, ptp4l, phys2sys, …)

System Clock

OC and BC PTP Events

AMQ Interconnect (Event Bus)

Redfish HW Events

OC and BC PTP and HW Events

DU Workload

RH Provided Event Bus Sidecar

Red Hat OpenShift / Red Hat CoreOS

Far Edge Hardware Platform

GMC - Grandmaster Clock   BC - Boundary Clock   OC - Ordinary Clock

PTP Operating Modes: OpenShift Node as an Ordinary Clock and Boundary Clock

Summary

Summary

- RAN Decomposition scatters the RAN functions (previously confined to the cell site) across the mobile network

- Cloud RAN Cell Sites can not be designed in isolation

- Cloud platform i.e. Red Hat OpenShift is the bedrock of the Cloud RAN infrastructure

- OpenShift is deployed at Cell Sites, Far Edge Sites and Edge Sites to host DU and/or CU functions

- OpenShift offers multiple Form Factors to suit the varying needs of RAN functions

- Rich range of OpenShift Operators to support Cloud RAN workloads

Further Reading and Upcoming Tech Talks

The Road to Cloud RAN: From 1G to 5G
https://www.redhat.com/architect/mobile-architecture-cloud-ran

20 radio access network (RAN) terms to know
https://www.redhat.com/architect/ran-radio-access-network-definitions

What does Red Hat OpenShift have to do with Cloud RAN?
https://www.redhat.com/architect/openshift-cloud-ran

Red Hat Telco Architecture, Solution and Products
https://www.redhat.com/telco

Blog Series on Red Hat Powered Cloud RAN and other topics
https://cloudify.network/

Mar 23rd: Deploying a Cloud RAN Network at Scale

Registration Open @ https://www.redhat.com/en/events/tech-talks