Open RAN: breaking the performance barrier

Research briefing for operators

Tuesday 13th December

In partnership with:

Red Hat
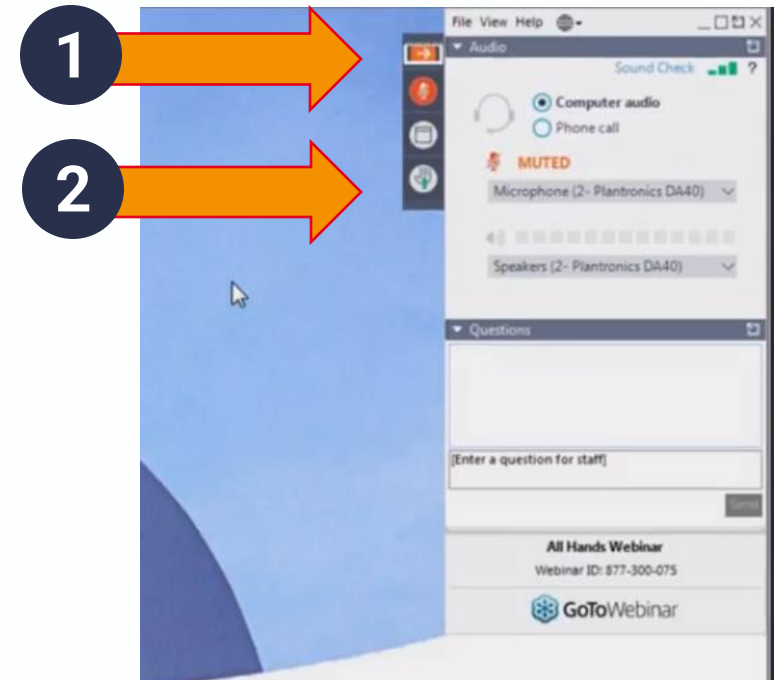
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Agenda

1	**Introductions and housekeeping**	5 min.
2	**Are performance and cost holding back adoption of Open RAN?**	20 min.
3	**Open RAN: improving telco energy efficiency**	10 min.
4	**Highlights of platform performance topics**	10 min.
5	**Q&A**	15 min.

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- Feel free to type questions throughout the session for Q&A at the end

- We'll send you the slides and a recording shortly after the session do share with colleagues

- On Twitter? Tweet us @STLPartners

Our speakers today

TIMO JOKIAHO

Chief Technologist, Telecom,
Media & Entertainment

Red Hat

**CHRIS
BARRACLOUGH**

CEO

STL Partners

MIRAN GILMORE

Senior Consultant

STL Partners
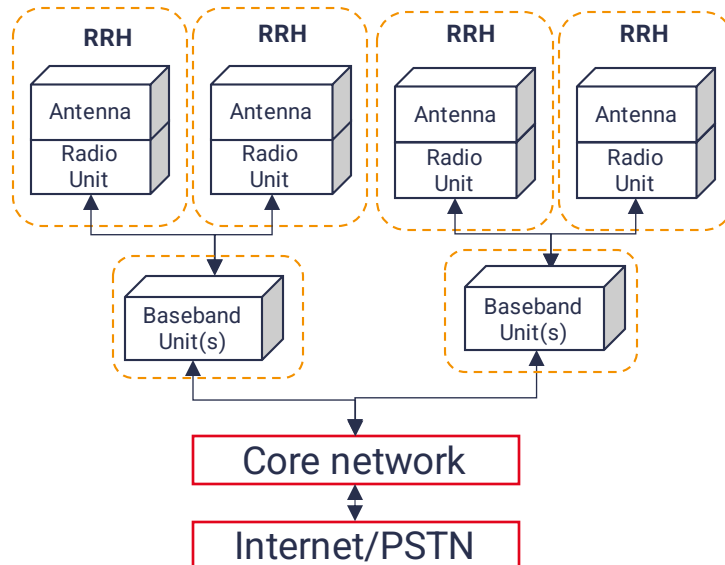
JOE HURMAN

Senior Consultant

STL Partners

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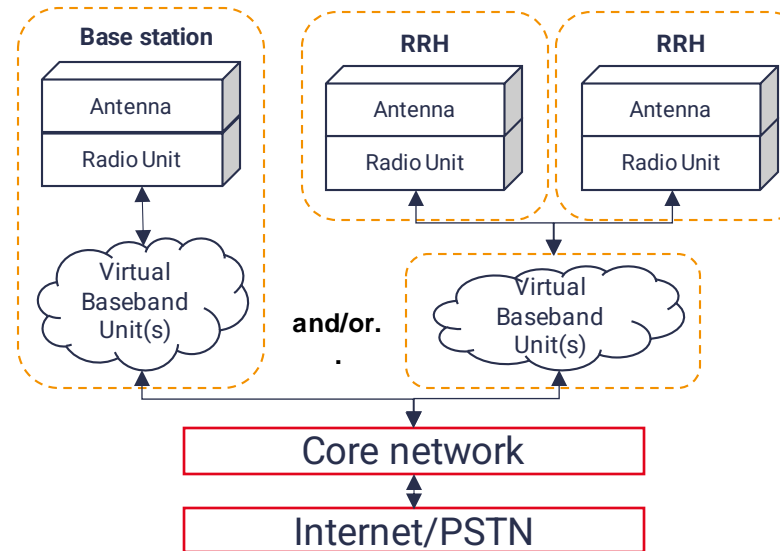# What is Open RAN? An umbrella term with three flavours

Open RAN

1 Cloud RAN (C-RAN)
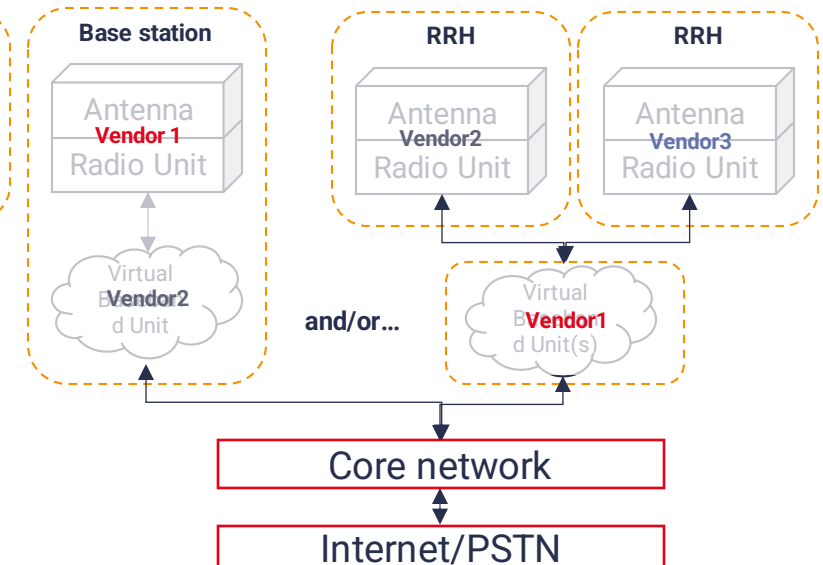Distributing and centralising baseband functionality across different locations

2 Virtual RAN (vRAN)
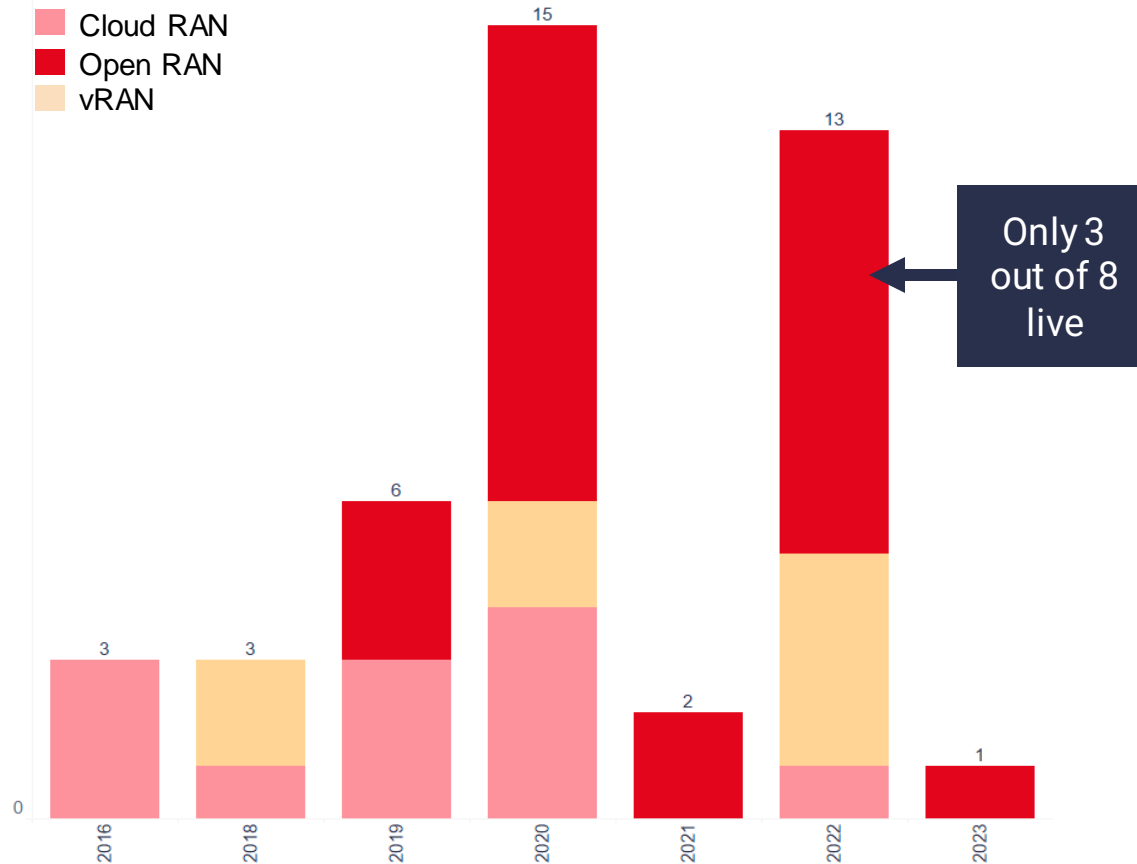Virtualising and containerising BBUs as software running on generic hardware platforms

3 Open-RAN (O-RAN)
Replacing legacy, proprietary interfaces between BBUs and RRHs with open standards

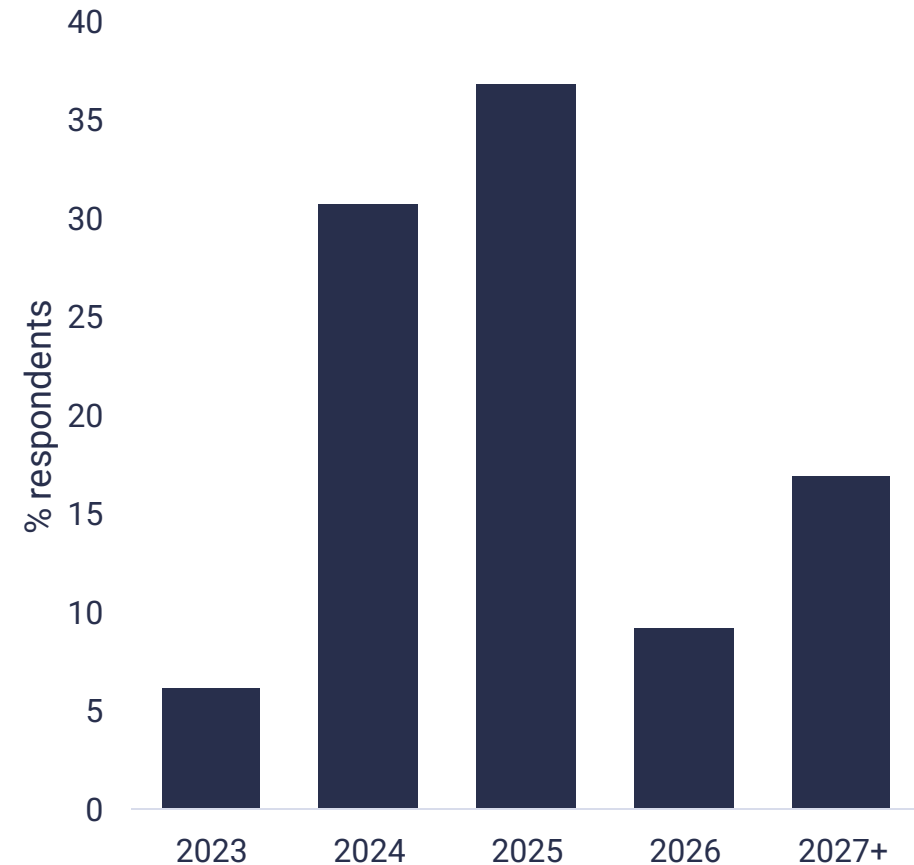# Adoption of Open RAN has been slower than expected, but the next few years will be a critical time of learning

Global deployments of C-RAN, vRAN and open RAN, 2016 to 2023

- Cloud RAN
- Open RAN
- vRAN

Only 3 out of 8 live

STL Partners telco cloud tracker data

When do you see the majority of mobile operators implementing Open RAN?
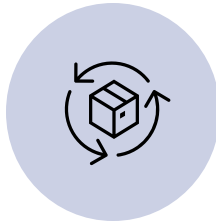

% respondents

STL Partners poll June 2022, n=65

Practical challenges to implementing Open RAN are being addressed, but it still suffers from hurdles of perception

Complexity of integration

Lifecycle management

Open ecosystem

Practical challenges

Hurdles of perception

Cost

Performance & service quality

Speed of deployment

Security

Poll: In your tests / trials, how is performance of Open RAN comparing to appliance-based RAN performance?

We have not yet started testing / trialling Open RAN	14
Performance is sub-optimal, expect parity within a year	1
Performance is sub-optimal, expect parity in over one year	7
Performance is roughly comparable	1
Performance exceeds that of legacy RAN deployments	0

Open RAN favouring
Non-Open RAN favouring

Technical performance data is scarce but there is evidence of continued improvements across borders and operators

1&1

Speeds of 1Gbps, 3ms latency and 8TB / customer / 24H

vodafone

O-RAN power consumption reduced by 9 – 12% during live trial at the University of Utah

vodafone

Achieved acceptable QoS levels for 2G-4G O-RAN deployments and exceeded 96 of their KPIs in 2019 and expected to achieve all their KPIs 'soon'

Jio

1 Gbps using a disaggregated 5G Open RAN solution (1.5+ Gbps is commonplace for vRAN 5G deployments)

airtel

1Gbps using in non-standalone (NSA) mode using commercially available 5G devices which is in line with legacy NSA performance

Rakuten

Open RAN RRHs only require 160W at high power vs. typical RRHs which require 870W at full power. Have achieved a 40% reduction in Opex and Capex combined

Until performance of Open RAN has been tested at a commercial level, it will be hard to prove performance parity

Current state

- Operators engaging in tests / trial deployments but unwilling to share results
- General sentiment is optimistic – with time and testing performance will improve

Practical challenges

Hurdles of perception

Future state

- Widespread adoption of O-RAN
  - *Greater innovation*
  - *Lower TCO*
  - *Diverse supplier ecosystem*
  - *New revenue opportunities*

"We have seen many performance figures that are satisfactory, and some that are not.

- Research & Trials Lead, Tier 1 EMEA Operator

"Open RAN is getting to be on par with traditional RAN [from a performance and energy consumption perspective], solutions will be on par soon.

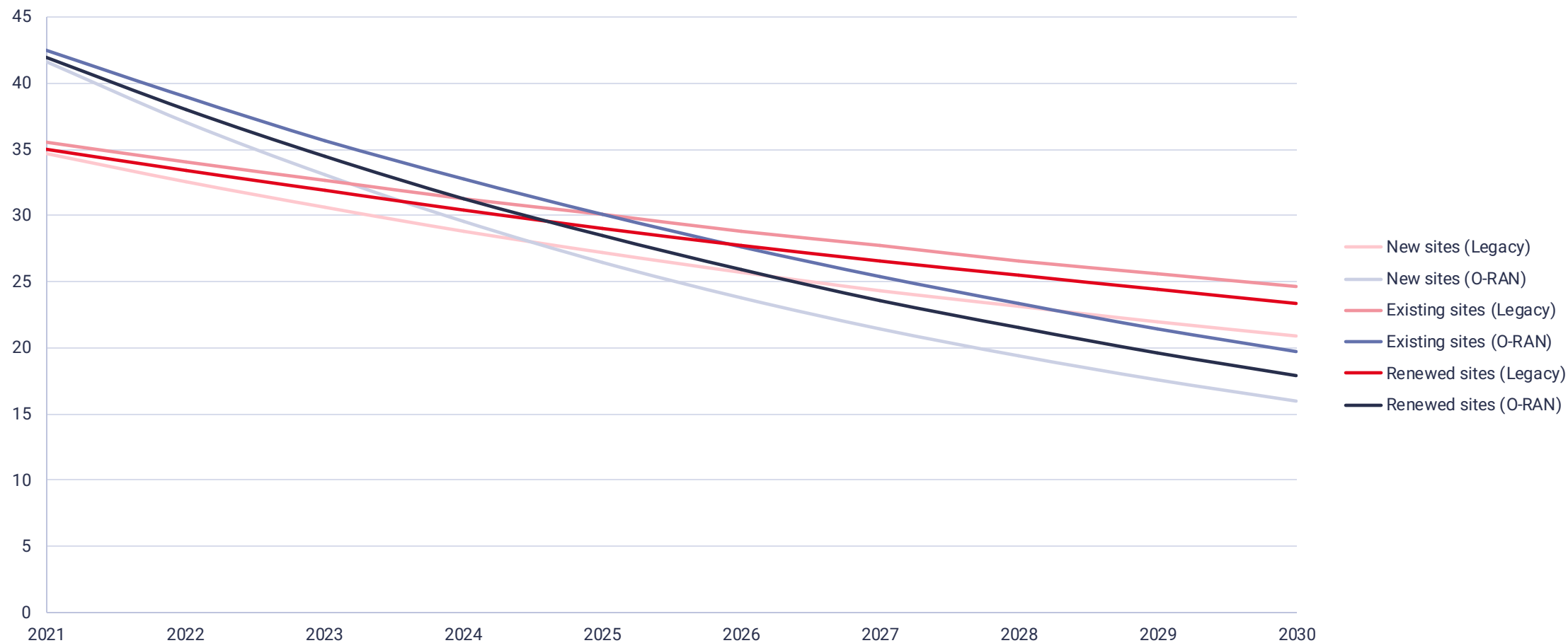*- Senior Partner Manager, Tier 1 EMEA Operator*

"We know the technology will work but will the financials really have benefits for the operator?

- Head of Radio Networks, Tier 2 EMEA Operator

2024 could be an inflection point for O-RAN adoption as Opex improvements start to come to fruition
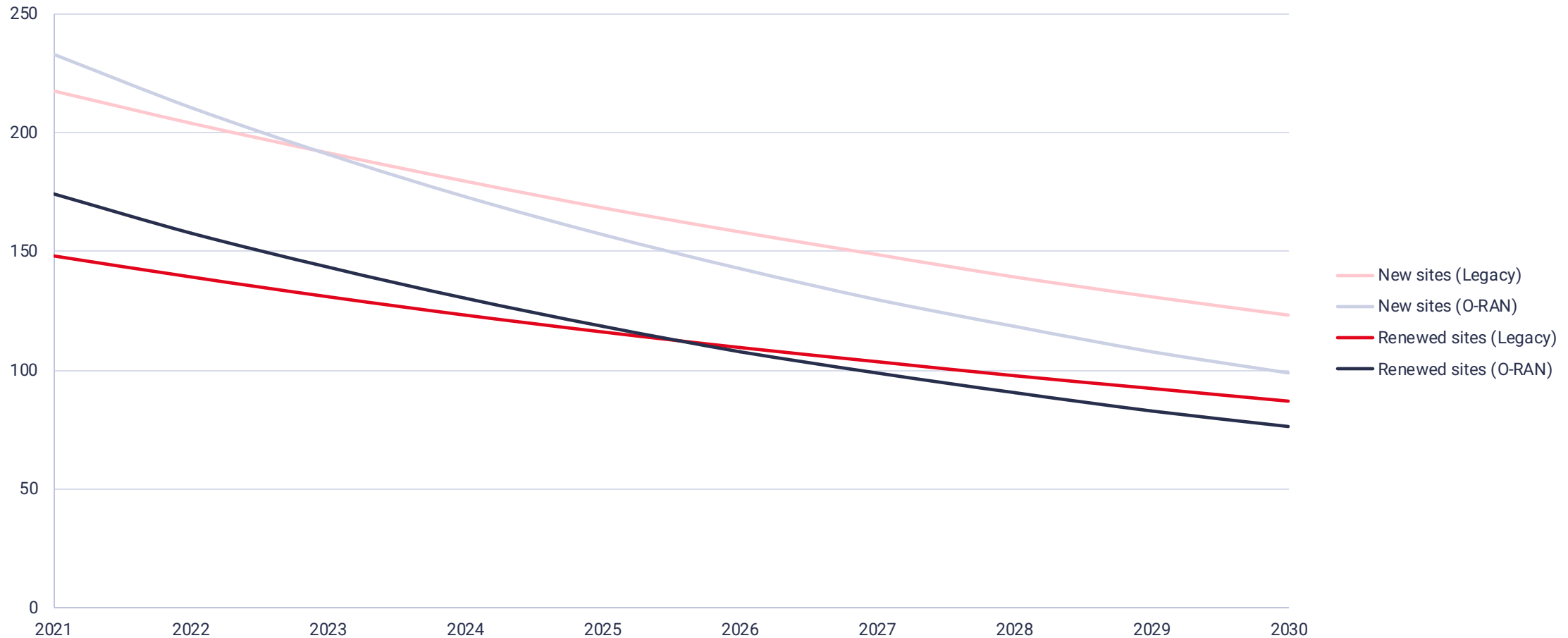
Opex per site split by site type ($000's)

Legend:
- New sites (Legacy)
- New sites (O-RAN)
- Existing sites (Legacy)
- Existing sites (O-RAN)
- Renewed sites (Legacy)
- Renewed sites (O-RAN)

Source: STL Partners & Sterlite research, 2021

O-RAN Capex benefits are clear for new-build sites but will take longer to materialise for renewed sites
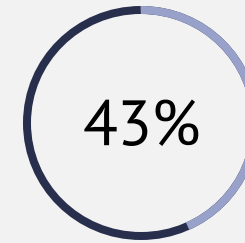
Capex per site split by site type ($000's)

Legend:
- New sites (Legacy)
- New sites (O-RAN)
- Renewed sites (Legacy)
- Renewed sites (O-RAN)

Source: STL Partners & Sterlite research, 2021

The net cashflow from Open RAN investment is compelling but relies on the assumption of fast technical progress

Net cashflow for a large EMEA operator in the $5-10bn revenue range moving to ORAN ($m)

Chart legend:
- ■ Annual net cashflow ($m)
- — Cumulative net cashflow ($m)

43% — 10yr ROI of 43% for this operator

Revenue expansion of ~1% due to edge use case enablement

Source: STL Partners & Sterlite research, 2021

Accelerating deployments of Open RAN will be key to driving performance gains and capturing benefits of Open RAN

The industry needs to be more open – about failures as well as successes – to accelerate this journey

Industry bodies could do more to define a clear roadmap to adoption of Open RAN

The RIC is a key point of differentiation between vRAN and true O-RAN; development efforts here are key

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The RAN is a major contributor to global emissions

Telecoms as a proportion of global energy consumption

2-3%

Total telecoms energy consumption

5%

9%

13%

73%

■ **RAN** ■ Core ■ Data centres ■ Operations

Source: GSMA, *Going green: benchmarking the energy efficiency of mobile*
June 2021

The RAN is a major contributor to global emissions

**The RAN is responsible for
1-2% of global energy consumption**

Telecoms as a
proportion of
global energy
consumption

2-3%

Total telecoms
energy
consumption

5%

9%

13%

73%

■ RAN ■ Core ■ Data centres ■ Operations

Source: GSMA, *Going green: benchmarking the energy efficiency of mobile*
June 2021

The GSMA breakdown of emissions is based on the following 4 domains

RAN
RAN
RAN

Network elements, energy sourcing, batteries, security, shelter

Core
Centralised / distributed unit

Network

Operations
Offices, retail

Data centres

Source: GSMA, *Going green: benchmarking the energy efficiency of mobile* June 2021

RAN energy consumption is up against a backdrop of sustainability rising up the agenda for all telco stakeholders

Employees

Customers

Government

Shareholders

Poll: In 5 years, how do you expect energy consumption of new Open RAN sites to compare to that of new appliance-based RAN sites?

	Value
Legacy RAN will consume over 50% more energy	1
Legacy RAN will consume between 25% & 50% more energy	1
Legacy RAN will consume up to 25% more energy	3
Legacy RAN & Open RAN will consume similar amounts of energy	11
Open RAN will consume more energy than Legacy RAN	6

Open RAN favouring
Non-Open RAN favouring

Open RAN is expected to be significantly more energy efficient than legacy within the next 5 years

RAN energy cost per site ($)

Legend: ORAN, Legacy

STL Partners research, 2021

Decreasing energy costs are expected to be the leading driver in reduced RAN Opex over the next 10 years

Change in Opex per site across key cost metrics for a new Open RAN site ($m)

Legend:
- Energy (ORAN)
- Salaries and personell (ORAN)
- Other network ops (ORAN)

STL Partners research, 2021

There are several key potential drivers of this expected increase in Open RAN energy efficiency

Consolidation of hardware

Improved development agility

Increased flexibility/ scalability

Innovative software solutions

However, debate remains over the energy efficiency of Open RAN in its current form…

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The greater flexibility enabled through automation creates scope for resource pooling…

- The operators who are actively investing in deploying and testing Open RAN feel these inefficiencies were inevitable in the early stages
- Not only is this true in a one-to-one analysis, more inefficiencies come from slow error isolation and inexperienced management
- These holes can be plugged when Open RAN deployment has the scale to enable resource pooling and network elasticity, ultimately allowing a reduction in network resources

"COTS power consumption can be more efficient when leveraging virtualisation to pool CUs and DUs using fronthaul"
- APAC greenfield operator

…but when comparing appliance BBUs with Open RAN BBUs, the traditional model is more power efficient

- The current architecture of the BBUs, along with the learning inefficiencies which come with new technology, currently reverse the power benefits Open RAN is theoretically meant to provide:

"The current architecture is less power efficient, the cost of integration is too high, and the need to upskill is too great ."
- EMEA operator

"Current power consumption figures show that Open RAN consumes more power than the traditional model."
- Initial O-RAN Alliance member

The automation efficiencies remain limited to greenfield operators who can deploy at the scale required to make notable savings. There will come an inflexion point where Open RAN becomes more power efficient, but this is likely still a few years out in live deployments.

Further industry collaboration will be required to accelerate the increase in Open RAN energy efficiency

The limited availability of quantitative data means it is challenging to draw any concrete conclusions about Open RAN energy efficiency...

> *Although some energy efficiency benefits can be seen in vRAN deployments, it's impossible to say the same for pure Open RAN works because these networks don't yet exist*
>
> **- Open RAN vendor**

Unless there is increased collaboration within the industry, the potential energy efficiency benefits that come with Open RAN will remain uncaptured

> *If there's an operator who wants to collaborate and share data with us, it'll help to significantly reduce time to feature parity*
>
> **- Open RAN R&D specialist**

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RAN Evolution: Two Dimensions of Architecture Transformation

RAN Functional Split
(disaggregation of functionality)

RAN Functional Split: **disaggregating baseband functionality from radio functionality**

RAN Cloudification
(disaggregation of HW & SW)

RAN Cloudification: **Deploy baseband functionality on consistent cloud platform**
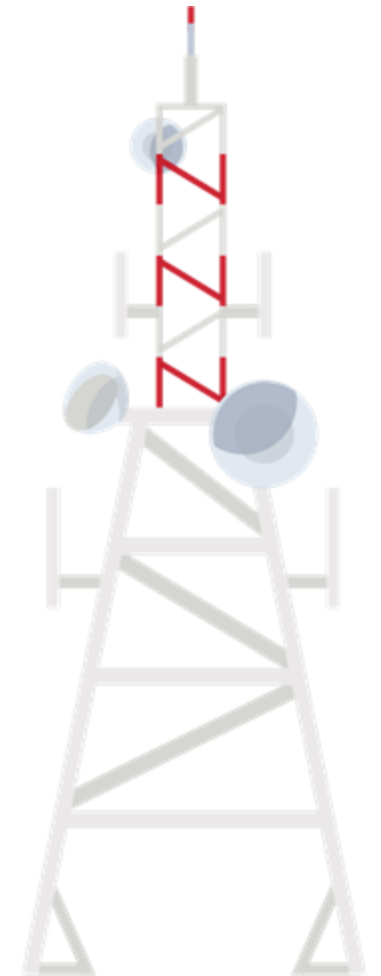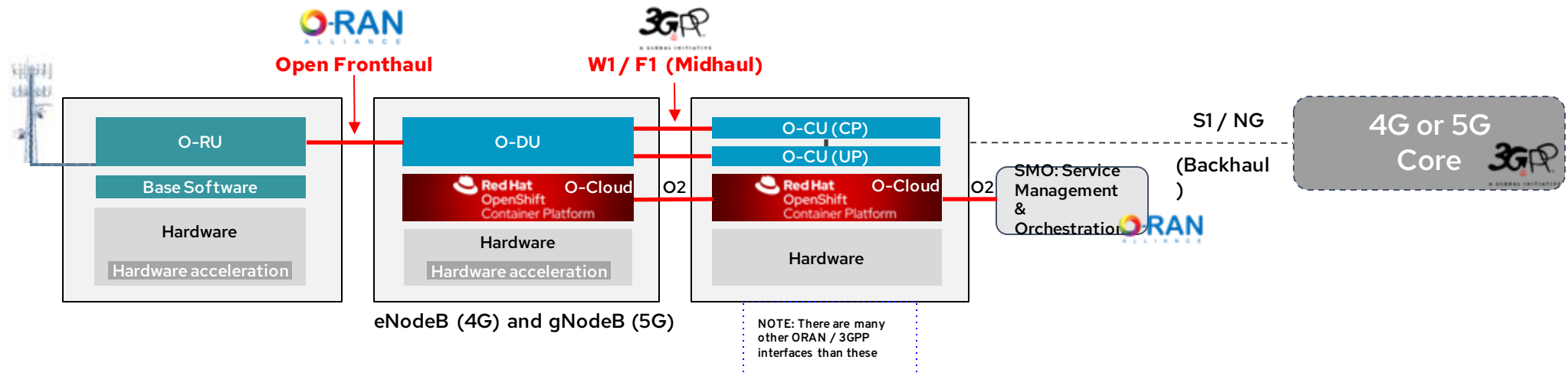
Mobile Network Radio Base Station

RAN Evolution: Open RAN Model aligned with O-RAN Alliance

**O-RAN Alliance
Compliant Model**

Open Fronthaul

W1 / F1 (Midhaul)

O-RU
Base Software
Hardware
Hardware acceleration

O-DU
Red Hat OpenShift Container Platform — O-Cloud
Hardware
Hardware acceleration

O2

O-CU (CP)
O-CU (UP)
Red Hat OpenShift Container Platform — O-Cloud
Hardware

O2

SMO: Service Management & Orchestration

S1 / NG
(Backhaul)

4G or 5G Core 3GPP

eNodeB (4G) and gNodeB (5G)

NOTE: There are many other ORAN / 3GPP interfaces than these

- Functional Split / Disaggregation per 3GPP
- Midhaul interfaces: W1 (Rel 16 for 4G) & F1 (Rel 15 for 5G)
- Standard interfaces (Backhaul) towards Core Network(s)
- Three entity model: Radio Unit (RU), Distributed Unit (DU), Centralized Unit (CU, Control and User Planes)
- O-RAN Alliance nomenclature: O-RU, O-DU, O-CU
- Cloud Platform to host DU and CU workloads
- O-RAN Alliance nomenclature for Cloud Platform: O-Cloud
- Goal: multi vendor

RRH = Remote radio head   RU = Radio unit
BBU = Baseband unit

DU = Distributed unit
CU = Centralized unit

UP = User plane
CP = Control plane

UPF = User Plane Function

S1 = 4G RAN and EPC interface
NG = Next-generation logical interface

RAN Evolution Adds New Requirements to Cloud Platforms

These are three of the most important new areas to cover ...

Realtime Kernel (RT Execution Environment)

Workloads stringent low-latency determinism requirements for core kernel features such as interrupt handling and process scheduling in the microsecond (μs) range.
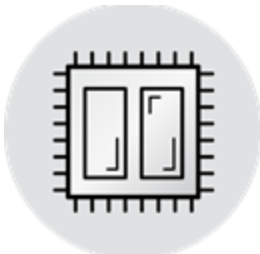
Timing & Synchronization

Time synchronization via transport networks will be critical for 5G radios. Precision Time Protocol (PTP) remains the preferred method to deliver timing across packet-switched networks

Red Hat Timing & Sync work presented at:
- International Timing & Synchronization Forum (Nov 5, 2020), Virtual
- OpenAirInterface Fall 2020 Virtual Workshop (Nov 12, 2020), Virtual
  Video: OpenAirInterface Event
- Workshop on Synchronization and Timing Systems (Apr 1, 2021), Virtual
  Slides: WSTS 2021
- International Timing & Synchronization Forum (Nov 3, 2021), Brighton, UK
- International Timing & Synchronization Forum (Nov 8, 2022) Düsseldorf, Germany

Hardware Acceleration

Field Programmable Gate Arrays (FPGA) , SmartNIC, and other hardware acceleration components will be vital for 5G virtualized infrastructure.

Red Hat

RAN Evolution Adds New Requirements to Cloud Platforms

CPU Management

CPU Manager manages groups of CPUs and constrains workloads to specific CPUs. CPU Manager is useful for workloads that have some of these attributes: require as much CPU time as possible or are low-latency network applications.

Topology Management

Topology Manager collects hints from the CPU Manager, Device Manager, and other Hint Providers to align pod resources, such as CPU, SR-IOV VFs, and other device resources, for all Quality of Service (QoS) classes on the same non-uniform memory access (NUMA) node.

Low Latency

A combination of multiple factors that allow the workload the maximum processing capacity and minimizes packet delivery latencies.

Zero touch provisioning

Provides all the tools required to install, upgrade and maintain the cloud infrastructure for the RAN workload with minimum user interaction in an "appliance" like deployment. Reduced complexity with increased flexibility of options and performance.
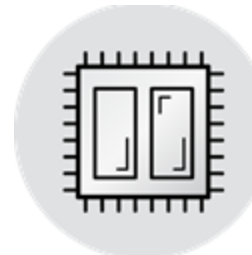
Remote Management

Take full control of edge and RAN operation from a centralized single pane of glass. This includes, OpenShift installation and upgrade, application provisioning and monitoring.

Reduce footprint

Remote Radio sites have limited space and power, therefore edge and RAN clouds would require a small cloud footprint.

OpenShift Performance Add-On Operator

- Provides deterministic application performance for latency sensitive workloads

- Intel EPA features

- HugePages Support

- CPU Pinning and Isolation

  - Provides CPU Manager with *'isolcpus'*

  - Intel CMK plugin functionality

- SR-IOV, DPDK and RDMA

- Real-Time Kernel installation and configuration

- Additional Operators Supported:

  - Node Topology Manager (NUMA)

  - Node Feature Discovery

    - GPU, FPGA, SR-IOV

Mobile Network Element UP NF Placement Locations;
5G Service Specific Slice Examples, Major Latency Components

1. Speed of light is ~300 km in one millisecond (in vacuum)
2. IP packet can travel ~200 km in one millisecond (in fibre)

Why Red Hat to secure 5G ?

1	**Containers are Linux**	Securing containers require deep Linux expertise
2	**Container Security**	Rootless containers, SELinux, Security Context Constraint (SCC),...
3	**Container OS**	Red Hat CoreOS for minimal surface of attack & easy LCM
4	**Container Confidentiality**	Different encryption mechanisms supported
5	**Product Security**	Track-record product support for security bugfix & backports
6	**Compliance at scale**	Compliance Operator & RH ACM for multi-cluster compliance
7	**Security Certifications**	FIPS 140-2, FedRAMP,...
8	**Security Automation**	Ansible Security, RH ACM, DevSecOps pipelines,...
9	**Platform Integrity**	Secure Boot, File Integrity Operator, Container scanning,...
10	**Security Partner Ecosystem**	Rich ecosystem of security partners

Security in O-RAN

▸ Defined in the SFG (Security Focus Group) – WIP

▸ Threat Modeling approach: assets, attack vectors, vulnerabilities and threats

▸ Risk assessment in terms of impact and likelihood

▸ Recommandations & best practices

REC–CM	Certificate Management
REC–NS	Network Segmentation & Filter Network Traffic
REC–IAM	Identity, Authentication and Access Management
REC–VHPM	Vulnerability Handling and Patch Management
REC–SCONF	Security Configuration
REC–SDLC	Secure Development Lifecycle
REC–SNFLC	Security VNF/CNF lifecycle
REC–IMGP	Image Protection
REC–LOG	Logging, Monitoring and Alerting
REC–SB	Secure Boot
REC–ISO	Strong Isolation
REC–AUD	Security Audit
`REC–SS	Secure Storage
REC–PHY	Physical Security Protection
REC–RA	Remote Attestation

O-RAN.SFG.O-CLOUD-Security-v09

OPEN RAN SECURITY WHITE PAPER

UNDER THE OPEN RAN MOU

by Deutsche Telekom, Orange, Telefónica, TIM and Vodafone

OPEN RAN SECURITY WHITE PAPER 1

Red Hat

Some Energy Efficiency Work Items

- Node level (single server)
- Cluster level (Openshift cluster)
- System level (entire multi cluster)
- Domain level (telco network domain like RAN)

Node level optimizations:

Heat Control   Frequency Scaling   Voltage Scaling   Clock Gating   Sleep States
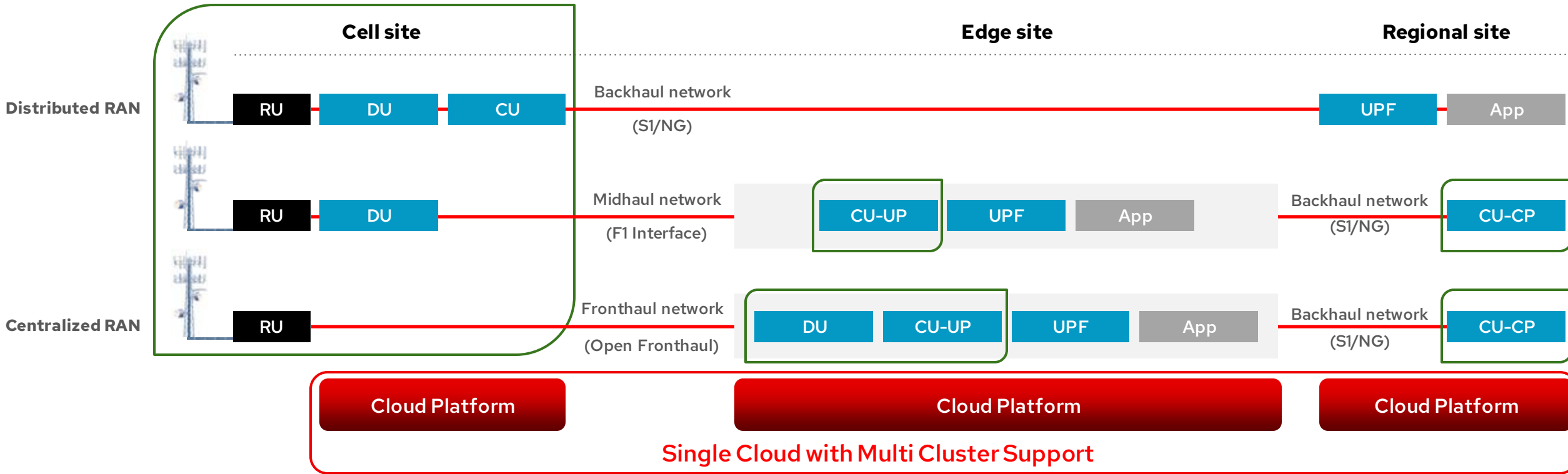
Some of the projects Red Hat is working on for sustainable computing include:

Upstream Projects (subset of ongoing projects)	
KEPLER[17]	The Kubernetes-based Efficient Power Level Exporter (KEPLER) is one of the tools Red Hat is sponsoring for the accurate identification of energy consumption on pods
KEDA[18]	Red Hat is working with the community to bring native CO2 and energy aware auto scaling capabilities to Kubernetes event-driven autoscaling (KEDA)
CLEVER[19]	Red Hat is working with the Container Level Energy-efficient VPA recommender to enable energy consumption metrics to be used for the vertical pod autoscaling for an application.
PEAKS[20]	Red Hat is working with the Power Efficiency Aware Kubernetes Scheduler (PEAKS) on a Kubernetes scheduler that will take power metrics into consideration for the scheduling of an application.

Recognizing these as cross-industry challenges, Red Hat is actively participating in communities and standard development organizations (SDOs) connected to these topics. Some examples of these communities include the cloud-native computing foundation (CNCF) environmental sustainability Technical Advisory Group, OS-Climate, O-RAN Alliance, and TM Forum.

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Deployment Models for Disaggregated RAN
And Consistent Cloud Platform ...

Cell site   **Edge site**   **Regional site**

Distributed RAN

RU — DU — CU   Backhaul network (S1/NG)   UPF — App

RU — DU   Midhaul network (F1 Interface)   CU-UP — UPF — App   Backhaul network (S1/NG)   CU-CP

Centralized RAN

RU   Fronthaul network (Open Fronthaul)   DU — CU-UP — UPF — App   Backhaul network (S1/NG)   CU-CP

Cloud Platform   **Cloud Platform**   **Cloud Platform**

Single Cloud with Multi Cluster Support

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RRH = Remote radio head   RU = Radio unit   DU = Distributed unit   UP = User plane   UPF = User Plane Function   S1 = 4G RAN and EPC interface

BBU = Baseband unit   CU = Centralized unit   CP = Control plane   NG = Next-generation logical interface

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